TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

PUBLIC HEALTH BULLETIN No. 86
AUGUST, 1917

INVESTIGATION OF THE POLLUTION OF CERTAIN TIDAL WATERS OF NEW JERSEY, NEW YORK, AND DELAWARE

WITH SPECIAL REFERENCE TO

BATHING BEACHES AND SHELLFISH-BEARING AREAS

By

HUGH S. CUMMING

PREPARED BY DIRECTION OF THE SURGEON GENERAL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

PUBLIC HEALTH BULLETIN No. 86

AUGUST, 1917

INVESTIGATION OF THE POLLUTION OF CERTAIN TIDAL WATERS OF NEW JERSEY, NEW YORK, AND DELAWARE

WITH SPECIAL REFERENCE TO

BATHING BEACHES AND SHELLFISH-BEARING AREAS

By

HUGH S. CUMMING

PREPARED BY DIRECTION OF THE SURGEON GENERAL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

ADDITIONAL COPIES

OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
20 CENTS PER COPY

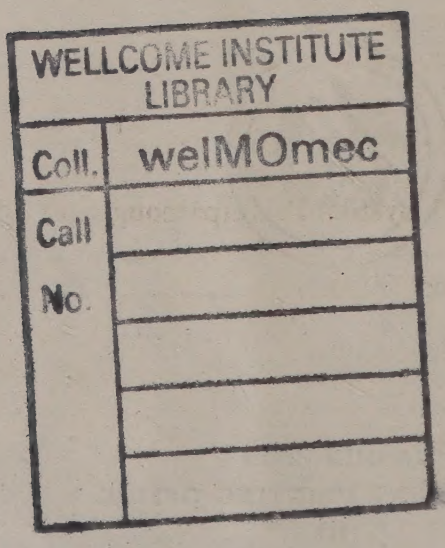


TABLE OF CONTENTS.

LIST OF MAPS AND CHARTS.

MAPS.

CHARTS.

LIST OF TABLES.

IN TEXT.

IN APPENDIX I.

DETAILED RESULTS OF EXAMINATIONS OF SAMPLES OF OYSTERS AND WATER AND DISSOLVED OXYGEN DETERMINATIONS.

INVESTIGATION OF THE POLLUTION OF CERTAIN TIDAL WATERS OF NEW JERSEY, NEW YORK, AND DELAWARE, WITH SPECIAL REFERENCE TO BATHING BEACHES AND SHELLFISH-BEARING AREAS.

By HUGH S. CUMMING,
Surgeon, U. S. Public Health Service.

INTRODUCTION.

The first investigation of the tidal waters of Maryland and Virginia with special reference to the pollution of shellfish having been completed,[1] these studies were extended to include the coastal waters of New Jersey, New York, and Delaware.

Arrangements were made with the department of health of the State of New Jersey for cooperation, through which a party was to use the shallow-draft launch *Inspector*, of that organization, for studies along the Atlantic coast of New Jersey, while the Public Health Service laboratory steamer *W. D. Bratton* was to be utilized for an investigation of the Delaware River and Bay and their tributaries and the waters of Raritan Bay.

At the request of the Chief of the Bureau of Chemistry, a conference was held by representatives of the Bureau of Chemistry of the United States Department of Agriculture, the New Jersey department of health, and the Public Health Service, during which it was stated that the authorities of the city of New York had forbidden the sale of oysters taken from the New Jersey side of Raritan Bay.

In view of the discrepancy between results obtained by the State board of New Jersey, the Bureau of Chemistry, and the New York authorities, and in view of the fact that oysters from the condemned areas were sold during the summer season, it was agreed that the Public Health Service should begin the investigation of the shellfish areas in Raritan Bay as soon as practicable. Accordingly, the laboratory steamer *Bratton* proceeded to Keyport, N. J., with a party which consisted of Surg. H. S. Cumming, Asst. Surg. C. E. Waller, Sanitary Engineer C. A. Haskins, and Bacteriologist H. V. Stewart.

The investigation of those waters was conducted from June 21 to August 20, 1915, when the vessel was moved to the Delaware River. The party returned to the vicinity of New York on November 12 and continued work until December 5, in order that the conditions prevailing during the period of change from moderate to low tempera-

[1] See Public Health Bulletin No. 74.

tures could be observed. This is the most important period of the shellfish business, from both the sanitary and economic points of view.

On August 25 the Delaware River studies were commenced, which alternated with those on Delaware Bay and its tributaries over a period of several months, the investigation being finished in December. At about the same time the investigation of waters on the Atlantic coast of New Jersey was begun, and conducted jointly by representatives from the State board of health and a party from this service.

In June, 1916, a reexamination of the water and shellfish of that portion of Raritan Bay and tributary waters on the New Jersey side was made in cooperation with representatives of the Bureau of Chemistry, United States Department of Agriculture, the State department of health of New Jersey, and the city of New York.

SCOPE AND METHODS OF INVESTIGATION.

Form of studies.—The studies took the following form:

1. A sanitary survey of the drainage area of the waters studied, with their tributaries, the survey including—
   - A. Character and amounts of sewage and wastes discharged into the waters.
   - B. Population on the watershed.
   - C. A study of the direction and velocity of currents and tides with reference to their effect on the pollution of certain areas and on the time factor in purification, etc., including the conducting of float experiments.
   - D. A study in detail of sanitary conditions in the vicinity of the shellfish beds and of the water in which they were situated.
2. The bacteriological examination of samples of oysters and water from the areas investigated, including oysters freshened or floated after being taken from the beds, and of sewage effluents from disposal plants discharging into the areas studied.
3. Chemical examinations for the determination of dissolved oxygen, etc.
4. A study of the amount and seasonal prevalence of typhoid fever in the communities adjacent to the waters investigated, with special reference to ascertaining what proportion, if any, of such cases were due to bathing in polluted water or to the ingestion of infected shellfish from such waters.

Technique of collection and examination of samples.—The method of collecting samples and the technique of examination were those which have been used in our previous investigations and described in Hygienic Laboratory Bulletin No. 104 and Public Health Bulletin No. 74, with the following exceptions:

Analyses of results obtained in previous examinations show that no considerable information as to infectious pollution can be obtained by the total colony count on agar at 20° C. from a composite sample of shell liquor. This opinion is held also by all the members of the committee of the American Public Health Association on standards for the examination of shellfish and by all other bacteriologists consulted; therefore a count upon agar at 37° was substituted.

In addition to the determination of the *B. coli* content and the total count, oyster and water samples were examined for streptococcus forms, from which, however, no information of definite value was obtained.

Determinations of dissolved oxygen were made according to the Winckler method as modified by Elvove.[1]

Floats.—The floats used were those constructed and used by the United States Coast and Geodetic Survey in connection with the investigation of the Potomac River by the Public Health Service, and were similar to those used by the Metropolitan Sewerage Commission in the investigation of the pollution in New York Harbor.

[1] Hyg. Lab. Bull. 96.

RARITAN BAY AND VICINITY [1]

GENERAL VIEW OF AREA.

DESCRIPTION.

The area covered in this investigation includes all of lower New York Bay west of a line from Fort Wadsworth (at the west side of the Narrows) southeastward to Sandy Hook, with Staten Island to the north and west, and the north shore of New Jersey to the south and west, together with the waters tributary to this area.

The area is triangular in shape, with the base east. Ten miles of this base is open to the sea. The waters entering this side of the triangle come from the Atlantic Ocean and through the Narrows from Upper New York Bay.

The southeastern portion of this area (lying west of and partially embraced by Sandy Hook, and extending as far as Point Comfort) is called Sandy Hook Bay. Into its southern portion discharge the Shrewsbury and Navesink Rivers through a common narrow entrance.

The apex of the triangular Raritan Bay area is about 15 miles west of the eastern entrance, and into it discharge the Raritan River [2] and Arthur Kill, which are the only tributaries of large size. No large streams on Staten Island discharge into the area, but there are two small bays, one of which, Great Kills, is a body of water with an entrance $\frac{1}{2}$ mile wide, opening southwestward. It lies about $6\frac{1}{2}$ miles southwest of the Narrows, is about $1\frac{1}{2}$ miles long, is shallow, and receives a small creek at its head.

Princess Bay is an identation in the Staten Island shore about $10\frac{1}{2}$ miles below the Narrows. A small stream called Lemon Creek discharges into Princess Bay.

There are several small tributaries of sanitary importance which discharge into Raritan Bay from the New Jersey (or south) side, including Cheesequake, Matawan and Lupatcong Creeks, and the Shrewsbury and Navesink Rivers.

The bay is of moderate depth throughout, the bottom sloping gradually from either shore to depths varying from 8 to 15 feet over broad areas of sand flats for distances of 1 to 2 miles on either side of the channel. However, the channel, from the junction of Raritan River and Arthur Kill, is narrow, deep, and hugs the Staten Island shore for $3\frac{1}{4}$ miles to Seguine Point, which marks the eastern end of Princess Bay.

---

[1] See Map No. 1.

[2] See map No. 2.

MAP 1.

NEW YORK BAY AND HARBOR

△ INDICATES WATER SAMPLING STATION.
○ " OYSTER " "
⌂ " WATER AND OYSTER " "
⊕ " SEWER OUTLET " "
□ " MUD " "

BATTERY, N.Y.
GOVERNOR'S ISLAND
NEWARK BAY
BAYONNE
UPPER BAY
ROBBINS REEF LIGHT
CONSTABLE PT.
BERGEN POINT
ELIZABETHPORT
KILL VAN KULL
ELIZABETH RIVER
GOWANUS BAY
BROOKLYN
BAY RIDGE
NARROWS
FORT HAMILTON
FORT WADSWORTH
GRAVESEND BAY
NORTONS PT.
CONEY I. LIGHT
CONEY I
RAHWAY
BRICKTOWN
RAHWAY RIVER
CHELSEY
PRALLS
FRESH KILLS
TUFTS PT.
ROSSVILLE
HOWARD BRIDGE CR.
VIEW CR.
STATEN ISLAND
GREAT KILLS
WEST BANK LIGHT
LOWER BAY
TOTTENVILLE
PERTH AMBOY
SANDY PT.
PRINCESS BAY
SEGUINE PT.
OLD ORCHARD SHOAL LIGHT
RARITAN RIVER
WARD PT.
SOUTH AMBOY
GREAT BEDS LIGHT
RARITAN BAY
CONASKONK PT.
PT. COMFORT
SANDY HOOK BAY
SANDY HOOK
MATAWAN PT.
MATAWAN CR.
KEYPORT
PT. ST. CR.
MILL CR.
COMPTON CR.
PORT MONMOUTH
SPERMACETI COVE
ATLANTIC HIGHLANDS
ISLAND BEACH
HIGHLAND BEACH
L. H. WILDER

NUMBERS OF LETTERED SYMBOLS AT CONASKONK PT.

A 213, 214, 230, 237, 266.	R 223.	
B 215, 231.	S 269	
C 232.	T 246, 249, 270, 277.	
D 210, 233, 238, 271.	U 184	
E 217.	V 222.	
F 218, 228, 239, 264, 272.	W 236, 262	
G 205, 225, 242, 259, 268, 276.	X 201, 202, 211, 221, 250, 278.	
H 210, 219, 227, 247.	Y 200, 220, 251, 279.	
I 234, 240.	a 142	
J 263.	b 141.	
K 209, 266, 273.	c 186.	
L 267.	d 185	
M 262.	e 192.	
N 204, 224, 243, 253, 260.	f 198.	
O 206, 207, 208, 226, 241, 252, 274.	g 193	j 197.
P 212, 229, 245, 248.	h 199.	k 196.
Q 203, 235, 244, 254, 261, 270.	i 194	l 195

On the south side of this western section of the channel the shoal reaches from the New Jersey shore northward to end in Round Shoal, the edge of which is only about 400 yards from Seguine Point. From this point a channel dredged to 19 feet depth for about 2,700 yards leads southeastward toward the middle of the bay. From about $1\frac{3}{4}$ miles south of Seguine Point there is a constantly widening area of water, from 20 to 30 feet in depth, toward the eastern limit of the area, where there are three deep passages connecting Raritan Bay with the eastern part of lower New York Bay and the Atlantic Ocean.

The configuration of the bottom on this eastern side of the area is of great importance in determining the direction and extent of currents to and from the Upper Bay or the ocean, and consequently the amount of pollution which may reach the Raritan Bay shellfish beds from New York Harbor on the one hand, and the dilution by ocean waters on the other.

Reaching from Fort Wadsworth southward for about 3 miles to a point below Swinburne Island, is a narrow bar called West Bank, over which the water has a depth of from $1\frac{1}{2}$ to 9 to 10 feet. Below Swinburne Island the water gradually deepens to a depth of 20 feet at West Bank Light.

Romer Shoal begins about 900 yards southeast of West Bank Light and extends southeastward for $3\frac{3}{4}$ miles, with depths varying from 3 to 15 feet.

South of Romer Shoal, and separated from it by the Swash Channel, are other shoals, including Flynn Knoll. Sandy Hook Point lies 1,200 yards south of Flynn Knoll and is separated from it by the main channel. Ambrose Channel is east of these bars and runs southeast from the Narrows to the ocean.

SHELLFISH AREAS.

New York side.—There are extensive oyster beds on both sides of the channel of Raritan Bay, the beds on the New York side covering the larger area and extending from near West Bank and around Old Orchard Light all along the Staten Island flats nearly to the Great Beds Light at the junction of the channels from Raritan River and Arthur Kill.

For convenience they may be described in three groups, beginning at the west: (*a*) The Princess Bay area, which lies on Round Shoal, across the channel from Princess Bay; (*b*) the Great Kills area, which extends from Seguine Point eastward and opposite Great Kills; (*c*) the Old Orchard area, which lies around that light and extends northeasterly toward West Bank and Hoffman and Swinburne Islands.

In addition, oysters grow in Great Kills and all along the foreshore of Staten Island, as well as in Arthur Kill. Approximately 20,000

acres or 30 square miles of beds are included in the oyster bearing area within the jurisdiction of the State of New York.

According to information courteously furnished by Mr. Emmett B. Hawkins, supervisor of the Bureau of Marine Fisheries, Conservation Commission of the State of New York, the cultivated oyster beds in Raritan Bay equal 8,800 acres. The value of the industry was not known:[1]

New Jersey side.—On the New Jersey or the southern side of the bay the only area of importance is that of Conaskonk Point, or Keyport Bar.

The region is of great commercial importance because of the immediate proximity of New York and other large cities, which consume great quantities of shellfish throughout the year.

The suitable hard bottom, the influx with each tide of enormous quantities of seawater, and the presence of abundant food swept down by streams combine to make the area of great value in growing oysters.

It is understood that most of the seed oysters are brought from Chesapeake Bay, Long Island Sound, and other outside districts, though a quantity are also grown in the beds around and westward of Princess Bay.

The oysters from the New York beds are used chiefly for winter trade, both shell and shucked; and large quantities are carried to Keyport, where, after immersion for one or more tides in Lupatcong or Cheesequake creeks, they are shucked or shipped as shellstock.

The industry of Keyport is very largely a summer one; oysters from Chesapeake Bay are planted during the early spring months on Keyport Bar or Conaskonk Point, taken up during the summer, allowed to "drink" in Lupatcong Creek, and sold as shellstock. Owing to the high *B. coli* score in oysters taken from Lupatcong Creek and Keyport Bar found by representatives of the Bureau of Chemistry of the Department of Agriculture and the board of health of New York City, the Interstate shipment of oysters from these sources or their entry into the city of New York was forbidden. In view of the trade being a summer one, it was considered advisable to investigate conditions during that season.

In addition to the oyster beds described, the flats and foreshores have many extensive hard clam or quahog (*Venus mercenaria*) and soft clam (*Mya arenaria*) producing areas. The flats of Sandy Hook Bay are especially prolific in clams and the industry is chiefly a summer trade, though the foreshores are fished for clams throughout the year. This industry is unorganized and is carried on by individuals.

In general, the industry on the New York side is to a great extent

[1] Letter Nov. 8, 1915.

controlled by large corporations which have other holdings elsewhere, while the Conaskonk Point or Keyport Bar beds are controlled by small dealers.

SCOPE OF STUDIES.

Following out the general scheme for the investigation, a survey of Raritan Bay and vicinity was conducted with the following objects in view: First, to estimate the quantity and character of the sewage and wastes from human sources discharged into the streams on the watershed of the bay; second, to find the effect of such sewage and wastes on the waters of the streams and the bay; and, third, to establish the presence or absence of the danger of infection of the shellfish beds or "drinking" grounds located within the bay or its tributaries. Studies were therefore made of the number of persons residing on the watershed, rural and urban, the sewer systems, and disposal of sewage from the communities, the courses and velocities of currents and tides through the bay, the shellfish, and the water in which the beds are located.

The sources of pollution of Raritan Bay may be enumerated as follows: (1) Communities situated on the streams which drain into the bay. (2) Communities situated along its shores. (3) Upper New York Bay (through The Narrows). (4) Shipping on the bay. This last is of such small amount in proportion to the large volume of water in the bay that it need not be considered.

Studies were made of the Raritan River, Arthur Kill, the Shrewsbury and Navesink Rivers, and currents from Upper New York Bay, which is polluted by sewage from the city of New York and several municipalities in New Jersey; and detailed inspections were made of the shores of the bay and the creeks used for "drinking" oysters.

In view of the enormous amount of work done and the data secured by the Metropolitan Sewerage Commission from 1906 to 1914 and made available through its valuable reports, no study was attempted of upper New York Bay itself or the communities contributing pollution to it. Frequent reference to the reports will be found throughout this bulletin.

RARITAN RIVER.

SANITARY SURVEY.[1]

With the exception of the Delaware, the Raritan is the largest river in New Jersey and is quite important, aside from its possibilities of power development, in that it is used extensively as a source of water supply and a means of sewage disposal by communities in its neighborhood. The river rises in the hills of Morris County and flows

[1] See Appendix II, page 135, for record of typhoid fever cases in New Brunswick, Perth Amboy, South Amboy, Borough of South River, etc.

in a generally southeast direction to Raritan Bay.[1] It drains 1,105 square miles of territory. From Fieldville dam to its mouth at Perth Amboy, a distance of about 17 miles, it is tidal and navigable. There are about 170,000 inhabitants on the drainage area, of whom 122,000 live in cities of 1,000 population or over. There are 16 cities, with a combined population of about 90,000, having sewer systems, but only 67,000 of the inhabitants of these cities are estimated to be tributary to the sewers. There are several factories on the watershed, employing about 6,000 persons. Some of these factories produce wastes of a more or less objectionable character. About one-half of the total watershed is tributary to lakes or streams furnishing domestic water supply; consequently the sewage from many of the towns on the upper drainage area is satisfactorily treated. Along the lower part of the watershed, however, sewage is discharged directly to the watercourses with no preliminary treatment. The following table, No. 1,[2] shows the places having sewer systems, population by the 1910 census, the estimated sewage flow, and whether or not the sewage is treated:

TABLE No. 1.—*Quantity of sewage and its treatment in cities along Raritan River.*

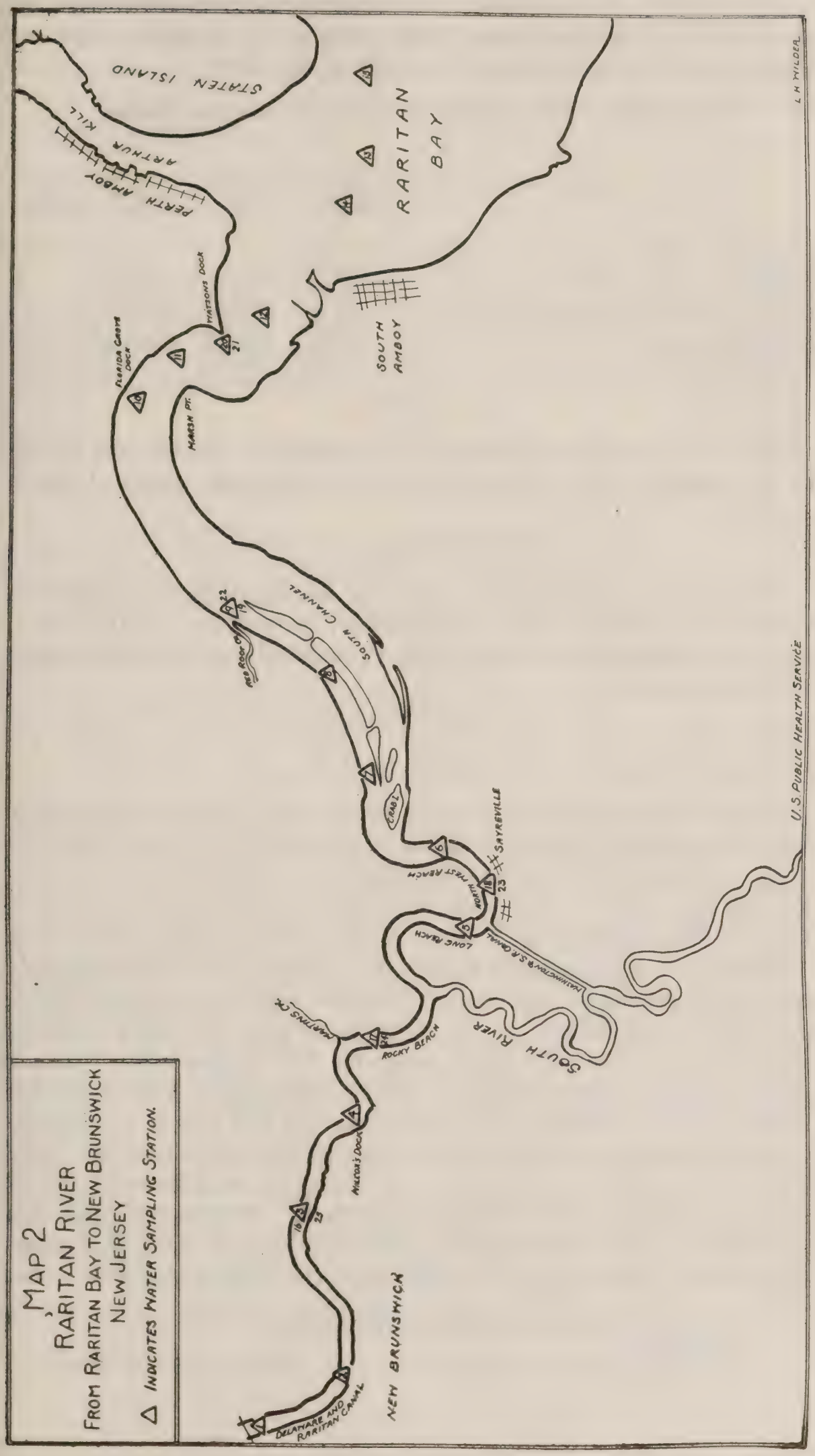
Place.	Population, 1910.	Name of stream.	Quantity of sewage.	Treatment.
			Gallons.	
Ralston	250	North Branch Raritan River	3,000	
Far Hills	350	do	15,000	Yes.
Glen Gardner	800	South Branch	50,000	Yes.
Flemington	2,800	do	200,000	Yes.
Hightstown	2,100	Millstone River	130,000	Yes.
Princeton	5,200	do	400,000	Yes.
Hopewell	1,070	do	15,000	Yes.
Skillman	400	do	50,000	Yes.
Jamesburg	1,600	South River	60,000	Yes.
Helmetta	660	do	15,000	Yes.
South River	5,000	do	150,000	No.
Plainfield	21,000	Green Brook	1,800,000	Yes.
South Plainfield	1,050	do	800	Yes.
Lincoln	300	do	30,000	No.
Milltown	1,500	Lawrence Brook	150,000	No.
Raritan	3,800	Raritan River	300,000	No.
Somerville	5,500	do	450,000	No.
Bound Brook	4,000	do	300,000	No.
Highland Park	1,600	do	115,000	No.
New Brunswick	23,000	do	2,300,000	No.
Perth Amboy [1]	10,000	do	1,000,000	No.
Total	91,980		7,555,800	

[1] About one-third of Perth Amboy sewage discharged into Raritan River.

About 7,500,000 gallons of sewage per day is discharged into the river or its tributaries, of which 4,500,000 gallons, more than one-half, is untreated. Practically all of the untreated sewage enters the river below Raritan and within 30 miles of its mouth.

[1] See map No. 2.

[2] State Board of Health of New Jersey, Annual Report for 1914.


MAP 2
RARITAN RIVER
FROM RARITAN BAY TO NEW BRUNSWICK
NEW JERSEY
△ INDICATES WATER SAMPLING STATION.
STATEN ISLAND
KILL
ARTHUR
PERTH AMBOY
RARITAN BAY
SOUTH AMBOY
THATSONS DOCK
FLORIDA GROVE DOCK
MARSH PT.
SOUTH CHANNEL
RED ROOF
CRAIG
SAYREVILLE
WEST BEACH
LONG BEACH
WASHINGTON'S S.R. CANAL
SOUTH RIVER
MANTUA'S CR.
ROCKY BEACH
MILLER'S DOCK
NEW BRUNSWICK
DELAWARE AND RARITAN CANAL
U.S. PUBLIC HEALTH SERVICE
L.H. WILDER

In Table No. 2 [1] are shown the places discharging raw sewage below Raritan; also the average daily stream flow in gallons and the theoretical dilution of sewage by water in the river.

TABLE NO. 2.—*Theoretical dilution of sewage of cities below Raritan.*

Place.	Sewage (gallons daily).	Total sewage flow (gallons daily).	Stream flow (gallons daily).	Theoretical dilution.
Raritan	300,000	.....	65,860,000	210
Somerville	450,000	750,000	67,880,000	90
Bound Brook	300,000	1,050,000	129,852,000	129
Highland Park and New Brunswick	2,415,000	3,465,000	134,932,000	300
South River	225,000	3,690,000	.....	.....
Perth Amboy (part of)	1,000,000	4,690,000	187,000,000	1,450
South Amboy	500,000	5,190,000	[1] 6,640,000	.....

[1] Tidal flow.

With this enormous dilution no evidences of sewage are visible in the river at New Brunswick and consequently none at Perth Amboy.

BACTERIOLOGICAL RESULTS.

Three series of samples of water for bacteriological examination were taken along the river in September, November, and December, from New Brunswick to Perth Amboy, the results of which are shown in Table A, page 84.

ARTHUR KILL.[2]

SANITARY SURVEY.

Arthur Kill is a narrow, winding, tidal stream, about 13 miles long, which separates the western side of Staten Island from the mainland of New Jersey. It connects Newark Bay and Kill Van Kull with Raritan Bay and is navigable throughout for ocean-going vessels. It is rapidly becoming one of the important shipping ports of New York Harbor. Except near its two ends the shores are rather sparsely populated, but there are many factories and an increasing urban population, particularly on the New Jersey side. It has a drainage area of only about 167 square miles (or 353 square miles if 17 per cent of Newark Bay and Kill Van Kull tributary to Arthur Kill are included). Its average flow of water on the ebb tide is about 330,000,000 cubic feet on each tide, or 4,936,800,000 gallons per day.[3] This includes the drainage from the Elizabeth and Rahway Rivers and Woodbridge Creek. The bulk of water, 297,000,000 cubic feet per tide or about 4,443,120,000 gallons per day, is tidal, and about 493,680,000 gallons per day represents the fresh-water flow. The

[1] State Board of Health of New Jersey, annual report for 1914.
[2] See Map No. 1.
[3] Report Metropolitan Sewage Commission 1912, p. 22. Ibid, Report 1914, Table CVI.

net ebb is 33,000,000 cubic feet. It is estimated that 17 per cent of the total discharge on ebb tide flows from Newark Bay, which is heavily polluted. Table No. 7 shows the places from which sewage is discharged into Arthur Kill, the population of the places, and their estimated sewage flow:

TABLE NO. 3.—*Sewage entering Arthur Kill.*

City.	Population.	Estimated sewage flow (gallons daily).
Perth Amboy (part of)	32,121	2,350,000
Woodbridge Township	5,500	500,000
Roosevelt (including Chrome, Carteret, and Port Reading)	5,786	[1] 683,000
Rahway (discharges to Rahway River)	9,337	1,000,000
Cranford and Garwood (discharge to Rahway River)	4,759	[2] 1,500,000
Linden	602	62,000
Joint trunk sewer [3]	43,229	11,100,400
Elizabeth [4]	73,409	9,000,000
Tottenville, Staten Island	.....	[5] 1,154,700
Total	173,743	27,350,100

[1] Includes 350,000 gallons from Maurer.
[2] Includes some factory wastes.
[3] Joint trunk sewer serves following places: South Orange, West Orange, Irvington, Milburn, Summit, Roselle Park, Newark (part of), 3,000,000 gallons daily; and Elizabeth (part of).
[4] Includes all of Elizabeth sewage.
[5] From gaugings by bureau of sewer plan, board of estimate and apportionment, city of New York.

Arthur Kill receives the wastes from about 50 factories in addition to those shown in the table, among them several oil and asphalt refineries and chemical works. These plants discharge wastes into Kill sufficient to cause a heavy "sleek" on the surface of the water most of the time. About 17,000 persons are employed in the factories on the shore of the Kill and Woodbridge Creek and are served either with sewers direct to the water or by overhanging privies. About 75 per cent of these persons live in the towns included in the table, but the remaining 25 per cent live in communities which are not sewered. Practically none of the sewage reaching Arthur Kill is treated. If all of the water on the ebb tide is considered available for dilution, neglecting that water below the tidal prism, there is a dilution of about 180 times; but this figure is too high, for the reason that sewage in Arthur Kill is carried backward and forward for several days before it leaves the Kill, as shown by various float tests made by the Metropolitan Sewage Commission of New York and described in the report of that body for 1914:

Float 61 December 16–18 showed:
Total distance traveled, flood, 16.97 miles in 21.5 hours.
Average velocity, flood, 0.79 mile per hour.
Maximum velocity, flood, 1.80 miles per hour.
Total distance traveled, ebb, 11.80 miles in 15 hours.
Average velocity, ebb, 0.79 mile per hour.
Maximum velocity, ebb, 2.33 miles per hour.

Also, a large amount of the water flowing into the Kill on flood tide is from Raritan Bay, which can not always be considered as unpolluted water, and a small part (0.17) is from Newark Bay, which, as has been mentioned, is seriously polluted.

The resultant flow of Arthur Kill is toward Raritan Bay.

BACTERIOLOGICAL AND DISSOLVED OXYGEN RESULTS.[1]

Various dissolved oxygen determinations and bacteriological examinations made of water from Arthur Kill during this study are shown in Table B (p. 85), an analysis of which is shown in Table C (p. 87).

A record of cases of typhoid fever in the territory adjacent to this area will be found in Appendix II (p. 135).

CONCLUSIONS.

These results indicate that a water with low oxygen content in summer and with *B. coli* present in 0.1 c. c. may be expected ordinarily from Arthur Kill at Great Beds Light, near which the flow from the Kill and that from Raritan River, with approximately the same *B. coli* content, unite on ebb tide to flow into Raritan Bay. This point is about 3 miles above the upper limits of the shellfish beds, from which oysters are taken to be floated and then sold as food.

The practice of bathing in this body of water, as was observed at Perth Amboy, Elizabethport, and other points along its shores is obviously dangerous and should be condemned.

WESTERN PORTION OF RARITAN BAY.

SANITARY SURVEY.

An examination of the map showing the topography of the bottom of this area [2] will suggest the probable direction of ebb currents from the above streams. One channel, which has been dredged to 19 feet depth, leads northeastward, hugging the Staten Island shore from Red Bank to Princess Bay and Seguine Point; north of Round Shoal it turns east and southerly through another 19-foot channel to the deep water. A wider, ill-defined channel of 11 to 15 feet depth leads eastward from Great Beds, past the south end of Round Shoal, to the deep channel between Keyport Bar and Round Shoal. The latter appears the most direct and probable course for both ebb and flood currents from and to Arthur Kill and Raritan River.

Float tests.—Six float tests were made by the Public Health Service party to determine the extent and the direction of the ebb current.[2]

[1] See Chart 1.

[2] Map No. 3.

MAP 3.

FLOAT TESTS IN NEW YORK AND RARITAN BAYS.

NOTE:— ELOATS 7, 55, 88, 90 AND U, ARE FROM REPORT OF THE METROPOLITAN SEWERAGE COMMISSION FOR 1914.

STATEN I.

ARTHUR KILL

PERTH AMBOY

TATTENVILLE

PRINCESS BAY

SEGUINE PT.

FERRY PT.

RARITAN R.

GREAT BEDS LIGHT

SOUTH AMBOY

RARITAN BAY

GREAT KILLS

FORT WADSWORTH

NARROWS

FORT HAMILTON

NORTONS PT.

CONEY ISLAND

WEST BANK LIGHT

OLD ORCHARD SHOAL LIGHT

LOWER BAY

CHEESEQUAKE CK.

STUMP CK.

CONASKONK PT.

PT. COMFORT

MATAWAN CK.

LUPATCONG CK.

KEYPORT

FLAT CK.

PORT MONMOUTH

COMPTON CK.

SANDY HOOK BAY

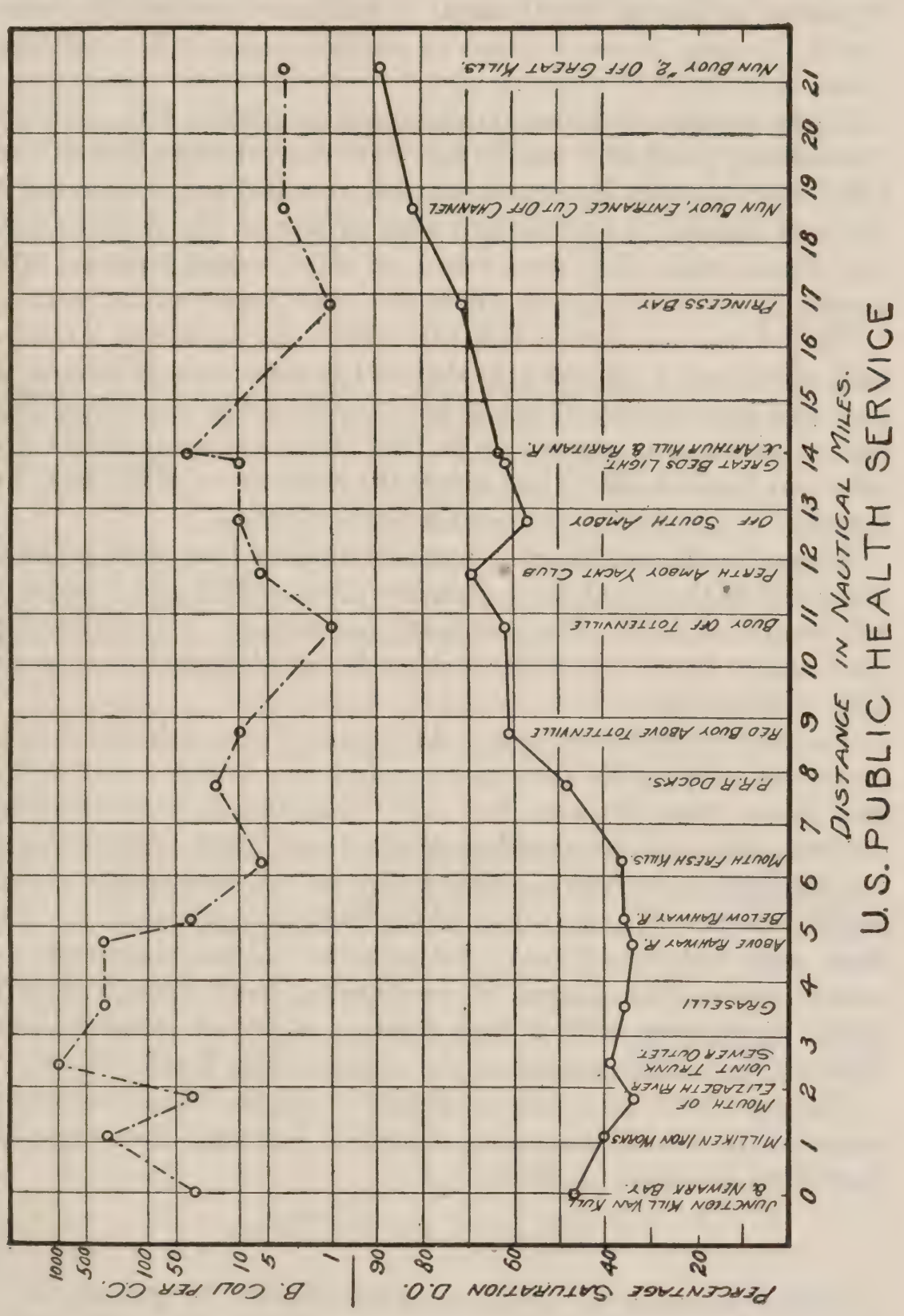
SANDY HOOK

ATLANTIC HIGHLANDS

U. S. PUBLIC HEALTH SERVICE

L. H. MILBER

A large Coast Survey type float (Float 6) was started at the beginning of ebb tide just below Great Beds Light, at the junction of the channel from Raritan River and Arthur Kill. The wind was light and negligible for this type of float and the stream flow about average.



The float started northeastward through the cut channel toward Princess Bay, followed the channel north of Round shoal, and then drifted in a southeasterly and southern course toward the middle of Raritan Bay, near black can buoy C. Flood tide was beginning

when the float was picked up after it had traveled 4 nautical miles in about six hours.

Floats 1 and 2 were set out in Arthur Kill opposite Perth Amboy and followed the channel down to the central channel and were taken up south of Round Shoal about a mile northeast of the boundary beacon, having traveled about 3½ nautical miles in five and one-half hours.

Floats 3 and 4 were set out together in Arthur Kill channel near the starting point of 1 and 2, and were carried down to the junction point with Raritan River, where they traveled northeastward in the dredged channel to the western edge of Round Shoal about opposite Red Bank, when they were taken up after having traveled approximately 2¾ nautical miles in about five and three-fourths hours.

Float 5 was set out on ebb tide above the mouth of Arthur Kill, near spar buoy 1 Q, and traveled to the west edge of Round Shoal, near the point where floats 3 and 4 were taken up, when the tide turned and it was carried up Arthur Kill to a point above Tottenville and Perth Amboy, just below the entrance to Mill Creek, having traveled in one flood tide about 4 nautical miles.

From the above studies it appears evident that such pollution as is present in the Great Beds area from Arthur Kill and Raritan River will be carried to the channels north and south of Round Shoal for at least one or two hours of each ebb tide, and longer during periods of heavy stream flow.

Factors in pollution of area.—At Seguine Point a dental instrument factory employing 600 persons discharges raw sewage into the Princess Bay area. Near Princess Bay Light the Mission of the Immaculate Virgin, with a total population of about 1,800, discharges about 200,000 gallons of raw sewage a day in the immediate vicinity of shellfish beds. While a study of the bacteriological results [1] does not show any evidence of heavy pollution in the neighborhood of these sewer outlets, the danger of discharging fresh sewage directly on oyster beds, even with a high dilution of water, must be realized. Both of the outfalls are across the channel from Round Shoal.

There are large areas of oyster grounds on the shoal, most of which are used for "seed" purposes, though it is stated that some oysters therefrom are used for food.

BACTERIOLOGICAL RESULTS.

Twenty samples of oysters and 42 samples of water were taken from this area in July and August and examined, with the following results: [2]

[1] See Table D (p. 88.)

[2] For details see Tables D and E (pp. 88 and 91.)

Only one sample of oysters scored as high as 23, while four gave scores of 14, and the others scored not higher than 5.

Of the samples of water taken with the oysters, *B. coli* was absent in 2, or 10 per cent in 10 c. c.; present in 18, or 90 per cent, in 10 c. c.; present in 11, or 55 per cent in 1 c. c.; and present in only 1, or 5 per cent in 0.1 c. c.

Of the remaining 22 samples of water taken in this area, 22, or 100 per cent, showed *B. coli* present in 10 c. c.; 19, or 86.3 per cent, showed *B. coli* present in 1 c. c.; and 8, or 36.3 per cent, showed *B. coli* present in 0.1 c. c. Seven of the eight samples showing *B. coli* present in 0.1 c. c. came from the upper end of the area, over a mile from the oyster beds.

CONCLUSIONS.

The presence of the two sewers and other local sources of pollution make it dangerous to use oysters from the foreshore north of the channel, but the bacteriological results obtained from the samples of oysters and water on Round Shoal indicate little pollution.

Bathing along the shores of this area is considered safe, except in that portion of the bay above Great Beds Light and in the neighborhood of local sources of pollution, such as exist at Seguine Point and opposite the Mission of the Immaculate Virgin.

EASTERN PORTION OF RARITAN BAY AND LOWER NEW YORK BAY.

SANITARY SURVEY.

The greatest possible sources of pollution of this area, in addition to those which have been already mentioned, are the cities the sewage from which is discharged into New York Harbor and thence through the Narrows into the Lower Bay.

The amount of sewage discharged into the harbor daily was estimated in 1910 as 604,000,000 gallons, and it is estimated that in 1917 the amount discharged will approximate 700,000,000 gallons daily.[1] In a short time there will be added to this quantity about 630,000,000 gallons daily from the Passaic Valley sewer.

Tides and currents.—The sources and approximate amounts of sewage which enter the region being known, a study of tides and currents was made to determine whether excessive pollution of the shellfish beds of this area might be expected from such sources.

According to the United States Coast and Geodetic Survey and the Metropolitan Sewage Commission,[2] the mean resultant or net flow seaward—i. e., excess of ebb over flood tide at the Narrows—is about 1,282,300,000 cubic feet per cycle of 12 hours, the resultant varying

[1] Karl Imhoff, p. 317, Met. Sew. Com. Rep., 1914.

[2] Pp. 179 et al., Report, 1910.

from 41 per cent greater than the mean to 46 per cent less than the mean. There is an excess of ebb flow of from 10 to 15 per cent, even in seasons of low river flow.[1]

As a result of many float tests, the commission concluded, regarding movements in the Upper Bay:

1. Floating matter starting in the channel near Robbins Reef may, within one tidal period, reach the shores of the Hudson as far as Sixtieth Street, Manhattan, or of Staten Island at any point in Kill Van Kull, Upper Bay, or Lower Bay, as far as South Beach. It may strand on the Brooklyn shore at any point south of Red Hook with a westerly wind, but a strong ebb current may carry it as far out as Romer Shoal. * * * (Robbins Reef is the point of discharge for the Passaic Valley sewer.)

4. Ordinary velocities encountered in the Upper Bay on flood are: Mean, 1.2 miles per hour; maximum, 1.8 miles per hour.

5. Ordinary velocities encountered in the Upper Bay on ebb tide are: Mean, 1.6 per hour; maximum, 2.5 to 3.1 miles per hour.[2]

The velocities of currents at the Narrows are: Mean ebb, 2.0; flood, 1.6 miles per hour; maximum ebb, 2.8; flood, 2.3; minimum ebb, 1.1; flood, 0.9.

The distance from the Narrows to the Battery at the lower end of Manhattan is about 4 miles, so that a large though undetermined amount of sewage is carried on one tide from the outfalls of Manhattan, Staten Island, and Brooklyn into the Lower Bay. This fact was established by various float tests.

The condition of the water at the Narrows, as determined by the commission, is shown in the following abstract:

Dissolved oxygen in July, 1909, 71 to 91 per cent of saturation on ebb tide and 85 to 100 per cent of saturation on flood tide. The table for 1911 shows 76 to 79 per cent saturation for all tides. Bacterial counts on gelatine at 20° averaged for all tides and depths 4,500 colonies per cubic centimeter; average, surface, 8,300; bottom, 1,900. Average number of colonies on flood tide, 2,500; ebb tide, 6,700. (There appears to have been no determination of the *B. coli* content.) Samples of mud taken from the bottom constantly showed evidence of gross pollution, and this area of bottom pollution appears to reach south almost to Sandy Hook.

It is estimated that even at the Narrows the velocity is slackened for 50 per cent of each total tidal cycle sufficiently to permit deposits of sewage solids (Table V, Report 1910).

In the lower bay "in the Main and Swash Channels the flood current starts in on the north side of the channel 15 minutes later than on the south side, and the ebb starts out on the south side of the channel 15 minutes earlier than on the north side. . . . The currents at half ebb in the Swash Channel set eastward strongly."[3]

A study of the surface appearances only suggests that a very large part of the ebb tide flow from the Narrows would spread somewhat and cause a heavy pollution on at least that part of the Staten Island flats which lie eastward of Old Orchard Light and Great Kills; but

[1] Coast Pilot, U. S. C. & G. S., and Met. Sew. Com. Report, 1910.
[2] Report, 1910, pp. 204–5.
[3] P. 32, Atlantic Coast Pilot V.

the West Bank already described acts as a jetty or breakwater to protect the area.

The mean prevailing winds in the district are from northwest throughout the year except during June and July, when they are from the southwest.

As a result of numerous float observations the Metropolitan Sewage Commission concluded:

> The most striking characteristic of the records, considered as a whole, is the fact that the currents in the middle of New York Bay run parallel to the Ambrose Channel and follows its turns at the upper end.[1]

That all of the water from the Narrows does not follow this channel, however, is shown by the following:

> A tendency to continue down the old Main Ship Channel instead of turning out to sea through Ambrose Channel was marked in some floats leaving the Narrows. These floats were all halted near West Bank or Romer Shoal light houses.
>
> Other floats dropped at these points on the first of the flood, either turned north toward the Narrows or went into Raritan Bay. In the former case they were likely to turn near Swinburne or Hoffman Island and go out by Ambrose Channel or return to West Bank Light. In the latter case, a float would go into Raritan Bay only to Old Orchard Light or a little further and return on ebb current.
>
> One float released off Sandy Hook at slack water went almost due west for about 4 miles on the flood current and then returned to a point near the starting place.[2]

In the report for 1910, p. 210, experiments were taken to indicate:

> 1. Floating matter is not likely to drift back into the upper bay if it has passed 6 or 8 miles below the Narrows.
>
> 2. Under certain conditions it may travel westerly to Raritan Bay to a point south of Great Kills, but ordinarily it will pass out to sea in a southeasterly direction.

The commission states [3] that the extreme points reached in a single tide by floats set adrift near Robbins Reef, the site of the Passaic Valley sewer outlet, were:

> In the lower bay 2⅜ miles southeast of West Bank, 11.50 miles in six hours; and 2 miles southwest of West Bank, 11.25 miles in 6 hours 30 minutes.

The report of the commission for 1910, pages 159 et seq., contains charts illustrating the set of surface currents during the tidal cycle. During the first and second lunar hours there is a set from the Narrows down the Staten Island shore; during the third hour this ceases. During the fourth lunar hour, while the ebb continues to bring down polluted harbor water from the Narrows, there is a set from the channel into Raritan Bay.

Floats 88, 90, and U (Metropolitan Sewerage Commission), in Map. No. 3, page. 18, illustrate the occasional course of the currents.

It is evident from the foregoing that some surface water from the Upper Bay does reach the Staten Island Flats around Old Orchard Light and to the north and east of this point.

---

[1] P. 508, Rep. 1914. [2] Ibid., Rep., 1914, p. 508. [3] P. 200, Rep., 1910.

The commission [1] refers to the fact that "sewage discharged in salt or brackish water tends to rise and float off at the surface." This is confirmed by the bacterial results obtained by the commission and by others, as well as by our own observations.

The tide over the Staten Island Flats off Great Kills opposite Elm Tree Beacon, up to Seguine Point, is weak, and the direction irregular.

A line of tide rip with floatage was observed frequently by the writer, reaching southeastward from about this area and marking the confluence of the ebb drift from Arthur Kill and Raritan River with that from the Narrows and the lower New York Bay.

Staten Island Flats.—The Staten Island Flats, bounded by a line extending from Seguine Point northeasterly to Hoffman and Swinburne Islands, thence in a southwesterly direction to Old Orchard Light, and thence to Seguine Point, include a large and important area of cultivated oyster beds.

To complete the survey of the shellfish beds lying on the north side of the bay, a close sanitary inspection of the south and east shore of Staten Island was made from South Beach to Tottenville. The sewage from the resorts at the lower end of the bay (South Beach, Middle Beach, etc.) is taken care of by cesspools which are regularly cleaned by scavengers. No sewer which discharges into the bay was found at any of the beaches. At Sea View Avenue, near the extreme northeastern limits of the shellfish beds, is a combined sewer of the Richmond Borough of the city of New York system, discharging directly into the bay with no treatment provided for the sewage.

BACTERIOLOGICAL RESULTS.[2]

Of 55 samples of oysters taken from this whole area during the first inspection, in July, August, and September,

6, or 10.9 per cent, gave scores of 140 or higher; 11, or 20 per cent, gave scores of 50 or higher; 17, or 30.9 per cent, gave scores of 41 or higher; and 30, or 54.5 per cent, gave scores of 32 or higher;

while of the same number of samples of water taken from over the oyster beds,

49, or 89 per cent, showed *B. coli* present in 10 c. c.; 34, or 61.8 per cent, showed *B. coli* present in 1 c. c.; and 17, or 30.9 per cent, showed *B. coli* present in 0.1 c. c.

Of the 36 samples of oysters taken during this period from that portion of the area eastward of a line drawn south from the west side of the entrance to Great Kills to Point Comfort on the New Jersey shore,

4, or 11.1 per cent, gave scores of 230; 5, or 13.8 per cent, gave scores of 140 or higher; 8, or 22.2 per cent, gave scores of 50 or higher; 14, or 38.8 per cent, gave scores of 41 or higher; 23, or 63.9 per cent, gave scores of 32 or higher;

---

[1] Rep., 910 (p. 183).

[2] For details, see Tables 4, D and E (pp. 88 and 91).

and only 13, or 36.1 per cent, scored less than 32; while of the samples of water taken therewith,

34, or 94.5 per cent, showed *B. coli* present in 10 c. c.; 28, or 77.9 per cent, showed *B. coli* present in 1 c. c.; and 15, or 41.6 per cent, showed *B. coli* present in 0.1 c. c.

Of 19 samples of oysters taken from the beds west of the above line, north of the main channel,

1, or 5.2 per cent, gave a score of 140; 3, or 15.6 per cent, gave a score of 50 or higher; and 7, or 36.8 per cent, gave a score of 32 or higher;

while of the samples of water taken therewith,

15, or 78.9 per cent, showed *B. coli* present in 10 c. c.; 8, or 42.1 per cent, showed *B. coli* present in 1 c. c.; and 2, or 10.4 per cent, showed *B. coli* present in 0.1 c. c.

The sample which scored 140 and one of the samples which scored 50 were taken on different occasions from the same place, about 700 or 800 yards off the Staten Island shore and about $1\frac{1}{4}$ miles westward of the entrance to Great Kills. Two samples taken nearer the entrance to Great Kills scored 41 each, with *B. coli* present in 1 c. c. quantities of water.

In addition to the samples of water taken with the oysters from this area during the first inspection there were 22 other samples taken. Of the 9 samples taken westward of the line from Great Kills to Point Comfort, 9, or 100 per cent, showed *B. coli* present in 10 c. c.; 7, or 77.7 per cent, showed *B. coli* present in 1 c. c.; and 3, or 33.3 per cent, showed *B. coli* present in 0.1 c. c. In the area east of the line *B. coli* was present in 13, or 100 per cent, of the samples in 1 c. c.; and in 9, or 61.5 per cent, in 0.1 c. c.

At the time of our second examination of this area the temperature of the water had fallen to about 6.5° C., and as a result the scores of the samples of oysters taken indicated a considerably lessened physiological activity of the shellfish. No sample of the 12 examined gave a score over 4.

Fourteen samples of water were taken at this time. *B. coli* was present in 12, or 85.7 per cent, in 10 c. c., and present in 4, or 28.5 per cent, in 1 c. c. Two samples not planted in 10 c. c. quantities were negative for *B. coli* in 1 c. c.

During the second examination two lines of water samples were taken from The Narrows down to Elm Tree Beacon, off the Staten Island shore, with the following results:

Off Fort Wadsworth, flood tide, *B. coli* absent in 0.01 c. c.; off Fort Wadsworth, ebb tide, *B. coli* present in 0.1 c. c.; off South Beach, flood tide, *B. coli* absent in 0.1 c. c.; off South Beach, ebb tide, *B. coli* present in 0.1 c. c.; off Middle Beach, flood tide, *B. coli* present in 0.1 c. c.; off Middle Beach, ebb tide, *B. coli* present in 0.1 c. c.; off Elm Tree Beacon, flood tide, *B. coli* present in 1 c. c.; off Elm Tree Beacon, ebb tide, *B. coli* present in 0.1 c. c.

CONCLUSIONS.

The origin of most of the excessive pollution over the part of this area in which the high scores were found is shown by the float tests U 90 and 88, of the Metropolitan Sewage Commission, shown on map No. 3, and our sanitary survey; and the bacteriological results, when considered in connection with these float results, and with the presence of the large sewer outfall at the foot of Sea View Avenue, justify the conclusion that oysters from the part of this area east of a line drawn south from the west side of the entrance to Great Kills to Point Comfort are subject to an excessive amount of pollution.

The sanitary condition of the oysters from the area west of the line must be considered doubtful during the warmer seasons, and those from the foreshore and near Great Kills should be considered unsafe, unless they be removed to nonpolluted waters until cleansed before being used as food.

While local disposal plants have been provided for the above-mentioned bathing resorts, obviously both decency and sanitary safety require proper purification of sewage from the Sea View Avenue sewer.

CONASKONK POINT (KEYPORT BAR).

SANITARY SURVEY.

The oyster beds on the New Jersey or south side of Raritan Bay are situated on a flat called Keyport Bar, which reaches northward to near the central deep water, nearly opposite Seguine Point. The bar is about 8½ miles west of Sandy Hook and 9 miles southwest of West Bank Light, at the upper end of Swash Channel. They are therefore beyond the range of one flood tide from this section and consequently are not now, nor will they be in the near future, in any danger of pollution from Upper New York Bay.

The beds are 4 miles distant from the mouths of Raritan River and Arthur Kill, but are probably out of the ordinary path of travel of the ebb tide from those streams, as is shown by the float tests, the contour of the bottom, and the bacteriological results obtained. There are, however, two possible sources of pollution on the New Jersey shore—sewage from Keyport and from Matawan.

Keyport sewerage system.—The sewerage system of the city of Keyport[1] covers practically the entire city and has about 400 connections at the present time, with a sewage flow of about 200,000 gallons per day. This sewage is all carried to one disposal plant, located on the shore near the foot of Broad Street (as shown on map No. 4). The sewage passes through either or both of two

[1] Population in 1910, 3,554.

settling tanks 12 by 90 by 7 feet, entering through a distributing trough extending across the end of the tank, and collecting at the outlet end through a similar trough. Suitable baffles and scum

MAP NO. 4.

boards extend across the tanks just in front of the troughs to prevent currents through the tanks. Suitable sludge wells are provided with a gasoline-driven triplex pump for lifting the sludge at cleaning periods, either to a disinfecting trough or to a wagon for

hauling it away. The settled sewage, on leaving the tanks, is supposed to be disinfected with a solution of hypochlorite of lime and then led through a mixing chamber, suitably baffled, before it flows out to the bay. Bacteriological examinations of the settled sewage and the effluent from the plant, as well as of samples of water collected from the bay over the submerged outlet, gave the results shown in the following table:

TABLE 4.—*Results of examinations of Keyport sewage and water over disposal plant outlet.*

No.	Date.	Time.	Samples.	Bacteria on agar 37° 48 hours.	B. coli.
					C. c.
1	June 25, 1915	11.15 a. m.	Water over sewer outlet in the bay	50	− 0.1
2	June 26, 1915	9.20 a. m.	do	90	+ 1.0
3	do	9.30 a. m.	Treated sewage	20	− 1.0
4	June 28, 1915	6.30 p. m.	Settled sewage	96,000	+ .001
5	do	do	Treated sewage	3,000	+10.0
6	do	do	Water over sewer outlet	435	+10.0
7	June 29, 1915	do	Settled sewage	77,000	+ .001
8	do	do	Treated sewage	1,150	+ .01
9	do	do	Water over sewer outlet	160	+ 1.0
10	June 30, 1915	8.30 a. m.	do	30	
11	July 1, 1915	5 p. m.	Settled sewage	103,000	+ .001
12	do	do	Treated sewage	6,000	+ .01
13	July 2, 1915	6 p. m.	Settled sewage	30,000	+ .0001
14	do	do	Treated sewage	1,060	+ .001
15	July 6, 1915	4.20 p. m.	Settled sewage	58,000	+ .01
16	do	do	Treated sewage	30,000	+ .01
17	July 7, 1915	11.30 a. m.	Settled sewage	180,000	+ .001
18	do	do	Treated sewage	30	+ .01
19	July 10, 1915	10.30 a. m.	Water over sewer outlet	72	+ 1.0
20	Aug. 10, 1915	do	Settled sewage	144,000	+ .001
21	do	do	Treated sewage	6,500	+ .01

A reasonable efficiency of treatment by this plant seems to depend principally upon the vigilance of the operator. One man has been detailed to visit the plant twice each day to make up "hypochlorite" solution and to see that things are working properly. Solutions are made up in two concrete tanks, 3 by 4 by 3 feet. One tank of solution is allowed to stand while the other is being dosed through a lead pipe to the effluent from the septic tank. The strength of the solution and continuous operation vary, of course, with the care of the operator, but frequent visits and analyses by representatives of the State board of health have insured a fair effluent at most times. The valve regulating the discharge of solution, which opens and closes with the varying sewage flow, clogs readily, and on several occasions it was found that no solution at all was feeding through it. Upon complaint of the State board of health an order was issued to the city to remodel the disinfection equipment. Steps are being taken to install a liquid chlorine plant to take the place of the "hypochlorite" arrangement, and in the meantime more frequent visits are being made to the plant by the operator. The proper disinfection of the Keyport sewage is extremely desirable for two reasons: First, the effluent is discharged into

Raritan Bay at a point less than 1½ miles away from the nearest oyster beds, and on ebb tide the effluent is carried out into the bay, passing directly over all the Keyport Bar beds; second, the point of discharge of the effluent is less than one-fourth mile from the mouth of Lupatcong Creek, where practically all the Keyport Bar oysters are floated before they are shipped, and it is possible that on flood tide sewage may be carried, in a very short time, from the point of discharge to the "drinking" ground. This will be discussed more fully further on in the report.[1]

Matawan Creek.—Matawan Creek is a small tidal stream draining about 15 square miles of rather densely populated area. The town of Matawan,[2] the only city of considerable size on the area, has a waterworks plant and a few small factories. It has no public sewer system. The practice of sewering from private places to the creek without any sewage treatment is common, a recent inspection by the State board of health having disclosed 75 sources of pollution of the creek by wastes from human sources. It is estimated that between one-third and one-half of the total population of the city is tributary to private sewers, which discharge into Matawan Creek. This is also true of a considerable floating population, since the hotels and railway station, used by several hundred persons a day during the summer season, are connected to sewers leading to the creek. The points of pollution are 1½ to 2½ miles from the mouth of the creek and 2½ to 3½ miles from the oyster beds. On ebb tide the polluting material, greatly diluted, is carried out toward these beds, and on flood tide some of it may be carried back up Lupatcong Creek, mentioned before, which discharges into a small bay just at the mouth of Matawan Creek.

BACTERIOLOGICAL RESULTS.

Fifty-eight samples of oysters were taken from Conaskonk Point, or Keyport Bar, for examination during our first inspection, from June to September. Of these—

None gave a score of over 50; 2, or 3.4 per cent, gave a score of 50; 9, or 15.3 per cent, gave a score of 41 or more; 13, or 22.1 per cent, gave a score of 23 or more; and 45, or 77.5 per cent, gave a score of less than 23.

Of 56 samples of water taken over the beds—

50, or 89.2 per cent, showed *B. coli* present in 10 c. c.; 31, or 55.3 per cent, showed *B. coli* present in 1 c. c.; and 20, or 35 per cent, showed *B. coli* present in 0.1 c. c.

All of the samples of oysters which scored 41 or more and nearly all of the samples of water which showed a high *B. coli* content were taken when there was high turbidity following rains. As is shown by the tables, the total count of both oysters and water jumped up immediately following the rains of August 1 and August 4.

[1] Page 31.

[2] Population, 1910, 1,646.

Of 21 samples of oysters taken on the writer's second inspection, only 1 scored 14 and 2 as high as 5. Of 20 samples of water over the area, 19, or 95 per cent, showed *B. coli* present in 10 c. c.; 13, or 65 per cent, in 1 c. c.; and 1, or 5 per cent, in 0.1 c. c. Of 7 samples of oysters taken on the joint survey in June, 1916, 1 scored 32, one 14, and the others 5 or less. The water samples showed 4 positive and 2 negative in 1 c. c.[1]

CONCLUSIONS.

On the basis of the sanitary survey and the bacteriological results obtained, it is the writer's opinion that oysters when taken from Conaskonk Point or Keyport Bar are free from dangerous infectious pollution even in the summer season and that bathing in the neighborhood of Keyport is a safe practice, provided that the sewage-disposal plant is efficiently operated and local pollution is prohibited.

LUPATCONG CREEK.

METHODS USED IN "DRINKING" OYSTERS IN LUPATCONG AND CHEESEQUAKE CREEKS.

Practically all oysters taken from Keyport Bar and a large number from other areas in Raritan Bay and elsewhere are freshened or "drinked" for varying periods of time in either Cheesequake Creek or Lupatcong Creek before they are shipped.

The method of "drinking" oysters in Lupatcong Creek differs from that in the Maurice and Cohansey Rivers in southern New Jersey, in Cheesequake Creek, where the oysters are placed on open-slat floats supported by pontoons; and from that at Chincoteague, Va., where there are tight inclosures into which land water and sea water are admitted in the desired proportions. Oysters are transferred from the beds or layings in the open water of Raritan Bay or elsewhere into Lupatcong Creek, where they are scattered over the bottom of the stream, allowed to remain in the less saline waters of the creek for one or more ebb tides, and then taken up and shipped either shucked or "in the shell."

SANITARY SURVEY OF LUPATCONG CREEK.

A few years ago there were several sources of pollution along Lupatcong Creek, a small tidal stream which flows through the western part of the city of Keyport and has a drainage area of about 3 square miles, but a vigorous campaign by the city officials, oystermen, and State board of health has resulted in the removal of practically all privies, stock pens, and drains from the creek. Storm sewers covering a portion of the city discharge street drainage to

[1] For details, see Tables F, G, and H (pp. 93, 94, and 97).

the creek either directly or indirectly, and it is thought by some persons that a few houses have toilets and sinks draining to these storm sewers. A close inspection of that entire portion of the city by Sanitary Engineer Haskins, of this service, a State board of health inspector, and the Mayor of Keyport on July 2 failed to establish any sources of pollution except two hog pens, one privy, and two sink drains along the entire creek. These were ordered removed by the State board of health shortly afterwards, and a subsequent inspection showed that the terms of the order had been carried out. Map No. 4 shows the location of the creek with respect to the city of Keyport, the location of the sewage-disposal plant, and the mouth of Matawan Creek. The location of the oyster houses and "drinking" grounds are also shown.

Float experiments conducted by the New Jersey State Board of Health seemed to show that the effluent which is discharged to the bay from the sewage-disposal plant would not be carried over the "drinking" grounds in Lupatcong Creek on flood tide at the location shown on map No. 4, but would pass the creek mouth and flow up the much larger Matawan Creek. To confirm this, bottle floats were set out by us over the sewer outlet on several different occasions. With a strong wind blowing from the east, the floats all followed the line AB. With the wind from the west, however, of three floats set out at the beginning of flood tide on June 29 near the end of the Ellsworth oyster house pier, as shown at point C, two followed approximately the line CD but the third followed the line CE into the mouth of Lupatcong Creek. Floats set out during the joint survey in June, 1916, followed a similar course, some of them going into Lupatcong Creek.

These results show that it is possible, under certain conditions, for the "drinking" grounds in the creek to be directly polluted by sewage from the city of Keyport, if extreme care is not exercised in the operation of the disposal plant.

BACTERIOLOGICAL RESULTS.

Tables I and J (pp. 98–100) show the results of the examination of 62 samples of water from Lupatcong Creek taken on the first survey. Excluding four samples the *B. coli* content of which was not obtained, of the remaining 58—

B. coli was absent in 4, or 6.8 per cent, in 10 c. c.; present in 5, or 8.6 per cent, in 10 c. c., but not in 1 c. c.; present in 16, or 27.5 per cent, in 1 c. c., but not in 0.1 c. c.; present in 32, or 55.1 per cent, in 0.1 c. c.; and present in 1, or 1.7 per cent, in 0.01 c. c.

Or, in—

54, or 93.1 per cent, *B. coli* was present in 10 c. c.; in 49, or 84.4 per cent, *B. coli* was present in 1 c. c.; in 33, or 56.8 per cent, *B. coli* was present in 0.1 c. c.; and in 1, or 1.7 per cent, *B. coli* was present in 0.01 c. c.

Of 19 samples of oysters examined at the same time after they had been deposited on the bottom of Lupatcong Creek for one or more tides (see Table I), one had a score of 410; one a score of 230; two had scores of 140; five scored 50; one scored 41; three, 32; two, 23; and four, 14 or less. Or, 21 per cent had scores of 140 or more and 47.3 per cent scores of 50 or more. It should be noted, however, that all samples scoring over 50 were collected at a time when the turbidity was high, following heavy rains.

During the second examination in November six samples of oysters floated in Lupatcong Creek for two to three days, with the temperature of the water ranging from 6° to 8°, were examined. Of these, one scored 50; one, 41; one, 32; two, 23; and one, 5.

Eleven more samples of water were taken on the joint survey in June, 1916. Of these, 4 were negative for *B. coli* in 1 c. c., 1 positive in 1 c. c., 5 positive in 0.1, and 1 positive in 0.01. Four samples of floated oysters taken at the time scored 1, 140, 230, and 500, respectively.

CONCLUSIONS.

Lupatcong Creek will undoubtedly be subject to possible infectious pollution so long as the operation of the sewage-disposal plant at Keyport is not reliable and pollution is discharged from Matawan Creek. Unquestionably the floating of oysters in any creek which runs alongside or through a town is fraught with potential danger, and such a practice should be discouraged by those responsible for the health of the people.

CHEESEQUAKE CREEK.

SANITARY SURVEY.

Cheesequake Creek is a tidal stream draining about 3 or 4 square miles of territory with an extremely small population. For a considerable distance on each side of the stream the land is flat and marshy, and, except near its mouth, there are practically no houses along its banks. This creek is utilized for "drinking" or floating many of the oysters taken from Raritan Bay and some from other localities. Near its mouth the creek is crossed by the New York & Long Branch Railway, by a public highway, and by a trolley line. Morgan is a small settlement near the mouth of the stream which is not inhabited to any extent except in the summer. On the beach just at the mouth of the creek there is a tent colony during the summer, and a few hundred yards back from the creek there are a few cottages and restaurants.

A close inspection of the creek on July 31 revealed two sources of pollution—one a toilet in a house overhanging the creek just west

of the railroad bridge, and the other an overhanging privy serving a small restaurant and a houseboat, also near the railroad bridge. Later both of these were ordered by the State board of health to be removed. The "drinking" grounds lie about one-half mile upstream from the settlement and extend for some distance along the creek. In the neighborhood of these grounds there is not a habitation of any kind. The mouth of the creek is located about $2\frac{1}{4}$ miles south of the sewer outlet of South Amboy and $3\frac{1}{4}$ miles northwest of the sewer outlet of Keyport. It is clear away from the direction of flow of any polluting stream or current.

Large quantities of stable manure are carried on barges from the city to a landing about a mile or more above the mouth of the creek and above the floating grounds for oysters. Large piles of this manure are seen on the fields near by, rotting and being prepared for use as fertilizer.

BACTERIOLOGICAL RESULTS.[1]

Of the four samples of oysters taken during our first examination of Cheesequake Creek only one scored as high as 14 after having been floated therein. During the reexamination of June, 1916, two more samples of floated oysters were taken, one of which scored 23 and the other 3. Of the 10 samples of water taken during 1915, all showed *B. coli* present in 1 c. c., but in no smaller quantities, while of the 14 samples taken in June, 1916, one sample showed *B. coli* present in one-tenth c. c., but no smaller quantities, and six showed the organism absent in the same quantity. The comparatively high colon score obtained was undoubtedly due to the traffic in manure already described, and such colon findings are without sanitary significance from a public-health standpoint.

CONCLUSIONS.

In the absence of any source of pollution from human sources and the known presence of stable manure, it is our opinion that from a sanitary standpoint this creek is a safe and good one for the purpose of floating shellfish. It is possible, however, that oysters shipped therefrom might sometimes show high bacteriological scores, which, in the absence of knowledge as to their source, might result in their condemnation under the present system of inspection and condemnation of shellfish by food authorities. In fact, this creek serves as a good example of the futility of endeavoring to establish the sanitary safety of shellfish by laboratory methods alone.

It may be stated here that, following the results obtained by the Public Health Service, the State of New Jersey, the Bureau of Chem-

[1] See Table K (p. 102).

istry, and the city of New York in June, 1916, it was determined by the City Health Department of New York to prohibit the shipment into the city of oysters floated in this creek; while a former decision prohibiting the importation of oysters from Keyport Bar was reversed. It was the unanimous decision of all parties interested that the floating of oysters in Lupatcong Creek was unsafe.

OTHER CREEKS ON THE SOUTH SHORE OF RARITAN BAY.

It is asserted by the oyster growers and others interested in the shellfish industry on the south shore of Lower New York Bay that the shellfish grown in that vicinity are not marketable without first being floated for the purpose of cleansing the oysters from sand, and, incidentally, giving them the appearance of being fattened.

In view of the decision of the Bureau of Chemistry and the city authorities of New York to forbid the shipment of oysters floated in Lupatcong or Cheesequake Creeks, a preliminary survey was made by the writer, in cooperation with representatives of the State Department of Health of New Jersey, of all of the creeks on the south shore which seemed suitable, with a view to finding if possible some creek free from dangerous pollution.

WHALE CREEK.

Whale Creek is a small estuary about half a mile west from Matawan Point at the entrance to Matawan Creek. The bacteriological findings varied from *B. coli* present in 0.1 c. c. in two samples and present in 1 c. c. in three samples near the mouth of the creek, to *B. coli* absent in 1 c. c. quantities in four samples in the upper part of the creek. The sanitary survey indicated that the creek is not to be recommended for the floating of shellfish because there is at least potential danger of infection incident to the more or less uncontrollable population upon its watershed; further, the fresh water is almost entirely surface drainage, varying greatly from time to time in character and pollution, usually carrying considerable clay. The creek is otherwise unsuitable for floating purposes.

CONASKONK CREEK.

This creek empties into Raritan Bay about halfway between Keyport and Conaskonk Point. Of twelve samples of water taken at intervals from a pond at the head of the creek, all of the samples showed *B. coli* present in 1 c. c., 10 of the samples showed its presence in 0.1 c. c., and two of the samples showed the organism present in 0.01 c. c. This creek is not recommended for floating of shellfish, as the sanitary survey shows that its head waters are liable to pollution consequent upon close proximity to human habitations in the

easterly end of Keyport; furthermore, it is not suitable for such a purpose because of its narrowness and the bar in front of its mouth.

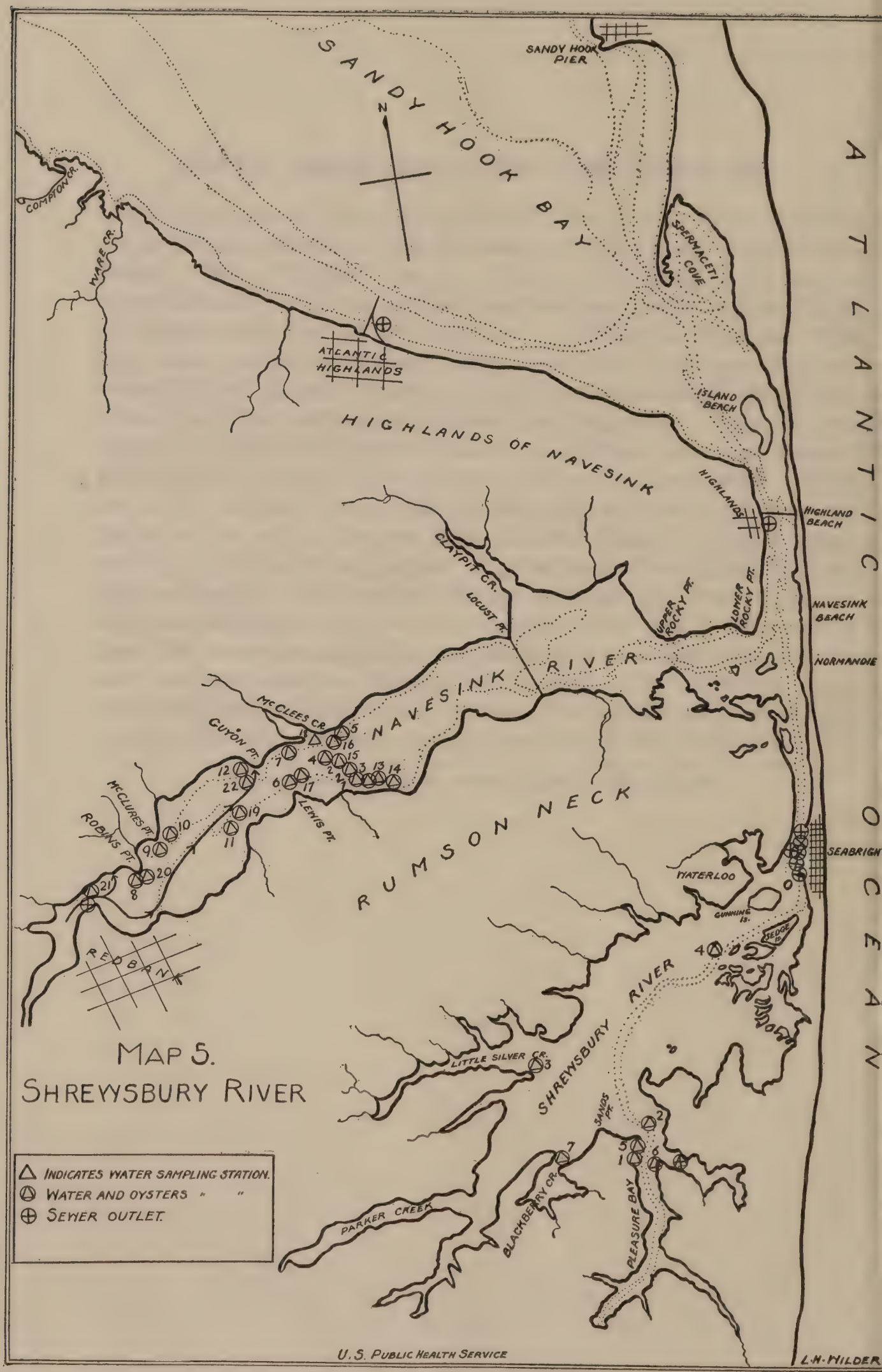
FLAT CREEK.

This creek discharges into the bight between Conaskonk Point and Point Comfort. Of the ten samples of water taken in this creek at various stages of the tide, all but three showed *B. coli* present in 0.1 c. c. The sanitary survey of the creek would seem to indicate that it could be made suitable for the floating of shellfish by the elimination of several easily corrected sources of pollution. A pigsty was found located upon the edge of the steep bank of a fresh-water pond at the head of the creek, the pollution from which could affect the bacteriological findings at ebb tide. Near its mouth there is a small stream which empties into the bay, the waters of which showed *B. coli* present in 0.01 c. c. This latter creek receives some pollution from a brickyard.

SOUTH SHORE OF LOWER NEW YORK BAY.

An inspection of the south and west shore of the Lower Bay was made, but no pollutions were discovered beyond those already mentioned. From Keyport east to Atlantic Highlands there are no communities of importance other than the beach resort at Keansburg. No sewers enter the bay at this point. At Atlantic Highlands [1] the city sewer system, with about 500 connections, discharges approximately 50,000 gallons of sewage daily directly into Sandy Hook Bay within less than a mile of extensive clamming areas. This city was ordered by the State board of health to construct a sewage disposal plant a few years ago, but to date nothing has been done. There are a few isolated connections to Many Mind Creek, and there are toilets at the end of the pier of the Central Railroad of New Jersey serving only 30 or 40 employees. A great deal of complaint has been made about the discharge of sewage and garbage from excursion steamers entering here, but it is probable that the total quantity from this source is negligible compared to the sewage from the city and the great dilution afforded by the bay. The taking of clams from the foreshore and vicinity of the above outfalls and the bathing in such waters are certainly not safe, and should be prohibited.

[1] Winter population, 1910, 1,645; summer population, estimated, 5,000.



MAP 5.
SHREWSBURY RIVER

69263°—17. (To face page 37.)

SHREWSBURY AND NAVESINK RIVERS.[1]

SANITARY SURVEY.

SHREWSBURY RIVER.

The Shrewsbury River rises near Long Branch, N. J., and flows northeasterly to Rumson, where it joins the Navesink. It is a tidal stream, with a drainage area of about 29 square miles. The sewage from Long Branch, the largest city on the watershed, is discharged directly into the sea. There are a great many private sewers and other sources of pollution which discharge into the various branches or tidal bays of the river, but public sewers of only two municipalities discharge into the stream. Seabright, with a winter population of 1,220 in 1910 and a summer population of several thousand, has a system of sewers discharging into the river at the foot of practically every street, in addition to which there are several private sewers. None of the sewage is treated.

Rumson, across the Shrewsbury River from Seabright, has a system of sewers, with a disposal system which consists of sedimentation tanks and hypochlorite of lime disinfection. There are several sewers from residences in the immediate neighborhood of the sewage disposal plant discharging sewage into the river without treatment. It is estimated that the flow from the city sewers amounts to about 50,000 gallons per day. It was impossible to obtain an estimate of the flow or number of connections to the sewer system at Seabright. Monmouth Beach has under construction a system of storm sewers discharging into the river near Pleasure Bay. It was stated by several persons that there are many house connections to this system, and the appearance of the effluent bore out these statements. The practice of constructing private sewers to the river seems to be generally followed where convenient.

NAVESINK RIVER.

Navesink River rises near Freehold and flows northeasterly about 17 miles to Sandy Hook Bay. It is joined at Rumson by the Shrewsbury River. It has a drainage area of about 95 square miles, and an average fresh-water flow of about 98,850,000 gallons per day, not including the discharge of the Shrewsbury. The river is tidal to Red Bank (for about 7 miles). The drainage area is quite populous, but the city of Red Bank[2] is the only place discharging sewage into the river. Red Bank has about 8 miles of sanitary sewers, with a

[1] See Map No. 5.

[2] Population, 1910, 7,398.

flow of about 300,000 gallons per day. It is estimated that about 60 per cent of the population of the city is connected with the system. The sewage flows to a disposal plant, consisting of grit chambers, septic tank, and hypochlorite of lime disinfection, before being discharged into the river, near the head of tidewater. An attendant with no other duties is provided for this plant, which seems to be quite well operated.

Results of analyses of treated sewage made by the New Jersey State board of health, along with bacteriological examinations of the raw and treated sewage made by the Public Health Service party are shown in the following table:

TABLE NO. 5.—*Red Bank sewage.*

Date.	B. coli per c. c.	Hypochlorite.
		p. p. m.
Dec. 16, 1913	10,000	8.3
June 2, 1914	10,000	8.5
July 18, 1914	10,000	9.0
Aug. 6, 1914	100,000	8.5
Sept. 4, 1914	10,000	10.3
Oct. 8, 1914	100,000	10.5
Apr. 8, 1915	1,000	11.0
Feb. 19, 1915	1,000	11.8
June 24, 1915	50,000	4.8

	Bacteria per c. c., agar 37° 48 hours.	B. coli present in —
July 7, 1915.		
Treated sewage	1,500	+0.1
Raw sewage	200,000	+ .001
July 8, 1915.		
Treated sewage	320	+10.0
Raw sewage	290,000	+ .01

Oysters are found in the Navesink River as far up as the sewage disposal plant, but the most of them are a few miles down the stream. In order to determine whether or not sewage from the disposal plant would be carried as far as the main beds in one ebb tide, a float was started opposite the disposal plant at high tide July 8, at 6.25 a. m. A light breeze was blowing from the south. At 8 a. m. this float was blown to the north shore and was reset in the main channel opposite the yacht club. At 12.30 the wind was blowing hard from the south and the float was again blown to the shore 2 miles downstream from the starting point. If time were taken out for that lost in taking up and resetting the float at 8 o'clock and that lost in finding it at noon, it is believed the rate of actual travel would have been sufficient to carry it to Fairhaven. On a normal day there is little doubt but that the effluent from the Red Bank disposal system would be carried over the entire shellfish area between the point

of discharge and the junction of the river with the Shrewsbury. This float test is shown on the map of this area.[1]

A close inspection of both shores of the Navesink disclosed two private sewers reaching the river from residences in Red Bank and one along the shore from Red Bank to Rumson. Two overhanging privies were found in the same area. From Seabright to Highlands there were four sewers from residences. At Highlands on both sides of the stream, as well as from many houses on the west shore, sewers from the restaurants and hotels were discharging directly to the river. At this point many house boats and small yachts anchor during the summer season, and there is undoubtedly a great amount of pollution from that source. The population reaches several thousand during the summer season at this resort, and it appeared that the greater part of the sewage was discharged in the vicinity of the "inside" bathing beaches. While there are no shellfish in the immediate vicinity, the danger from this source to clams in Sandy Hook Bay and shellfish in both Shrewsbury and Navesink River must eventually be of an appreciable magnitude. Below Highlands a septic tank serving 40 or 50 persons at Waterwitch discharges a particularly offensive effluent into an arm of Sandy Hook Bay. From this point to Atlantic Highlands no sources of pollution were found.

BACTERIOLOGICAL EXAMINATIONS

A number of samples of oysters and water were taken over the shellfish areas in both streams.

Of 21 samples of oysters taken from the beds of Navesink River—

2, or 9.5 per cent, scored 32; 3, or 14.3 per cent, scored 23, and none of the remainder scored over 5.

Of the same number of water samples, 19 of which were taken with the oysters—

All showed *B. coli* present in 10 c. c.

13, or 61.9 per cent, showed *B. coli* present in 1 c. c.; 3, or 14.3 per cent, showed *B. coli* present in 0.1 c. c.

In the Shrewsbury River four samples of oysters and clams were taken in Pleasure Bay, along with the same number of samples of water. The oysters gave scores of 23 and 14, while each of the clams scored 2. Of the four water samples—

All, or 100 per cent, showed *B. coli* present in 10 c. c.; 3, or 75 per cent, showed *B. coli* present in 1 c. c.; 1, or 25 per cent, showed *B. coli* present in 0.1 c. c.

A sample of oysters from Little Silver Creek scored only 3, with the water positive for *B. coli* in 1 c. c.

Oysters from Blackberry Creek scored 2, and the water showed *B. coli* present in 10 c. c.

---

[1] Map No. 5.

A sample of clams from near Gunning Island scored 3, with the water positive for *B. coli* in 10 c.c.

Results of examinations of Navesink and Shrewsbury Rivers are shown in Tables L and M (pp. 103 and 104).

CONCLUSIONS.

Under winter conditions, when there are few boats on the Navesink River and there is no summer population near the mouth of the stream at Highlands, there will be little danger of pollution of the shellfish beds from about Guyon Point down toward Oceanic, and it is believed that the oysters and clams from this vicinity will be safe, provided that the disposal plant at Red Bank is efficiently operated.

During the summer the number of persons who contribute pollution from boats and directly from the shores is so large that it is believed that shellfish from this area should not be used raw.

Bathing in the waters adjacent to the inlet and at the inside bathing beaches near Highlands must under existing conditions be considered unsafe as well as uncleanly.

There are few oysters in the Shrewsbury River and the dilution is enormous. It is evident, however, that shellfish from the south bank and Pleasure Bay are subject to pollution and should not be used for food. The small areas around Blackberry and Little Silver Creeks appear to be free from danger of serious pollution. Clams from near the mouth of the river and from around Gunning and Sedge Islands are subject to pollution from Seabright and are unsafe, more particularly during the summer season.

SANITARY CONDITIONS IN RARITAN BAY AS A WHOLE.

It is evident from the sanitary survey and from the bacteriological results obtained that no part of this bay can be considered entirely unpolluted. There is, however, in the light of present knowledge, no reasonable evidence which would justify at present the condemnation of all shellfish-bearing areas in the bay; though it should be borne in mind that the amount of pollution is being constantly augmented as the result of the growth of the present contributing communities and that it will probably be enormously increased when the Passaic Valley sewer is completed.

The tidal and current studies have shown that the time factor, or interval between discharge of sewage and its arrival over the oyster beds, is not great. Therefore dilution, which is very great in some sections of the bay, must be regarded as the most important determining factor of safety.

The pollution in the bay is chiefly urban in origin, hence in large part from human sources, and therefore potentially dangerous.

Decision as to the sanitary safeness of any section of the bay therefore must be based upon the amount of pollution present as measured by the *B. coli* content, together with proximity of such section to possible sources of intermittent infectious pollution.

Shellfish from foreshores, particularly in the immediate vicinity of sewer outfalls, or even of communities without sewers, are generally to be condemned as raw food. Such localities, even where repeated examinations fail to show large amounts of pollution, may be subject to sudden, intermittent, and dangerous infectious pollution, and to such infections have been traced most of the typhoid fever outbreaks consequent upon eating infected shellfish.

Areas in open waters away from such dangers, away from the channel drift from New York and other sources of pollution are different from the above; in some of them the amount of pollution is small and its character fairly constant. After thorough study over a considerable period of time both these factors can be predicted. The evidence pointing to infectious disease being carried by shellfish from these latter areas is at least indefinite. Inasmuch as purification of oysters by the use of hypochlorite of lime, or chlorin, however, has been shown by the Service after experimentation at Fisherman's Island,[1] to be possible and to be of practical value in Jamaica Bay, it is believed particularly applicable to shellfish from most of the sections of Raritan Bay and is recommended for adoption.

While our observations at Fisherman's Island and elsewhere, and those of other investigators, have shown conclusively that oysters admit some water even during so-called hibernation periods, nevertheless their activity during such period is lessened, the quantity of water taken in is greatly decreased, and hence there is diminished danger of infection even though the water contain pollution. There are oyster-bearing areas, therefore, the shellfish from which are unfit for use as raw food during warm seasons when active feeding results in the accumulation of organic matter, including bacteria, both within the oyster and in its liquor, but from such areas oysters may be eaten with impunity during hibernation. We do not believe, however, that oysters from all polluted beds are safe during such periods even if bacteriological results therefrom fail to show heavy pollution; there is, in our opinion, potential danger at all times in oysters from grossly polluted waters and in those from localities liable to pollution perhaps small in amount but recent and infectious in character.

Before areas are declared safe because of hibernation, the fact of its existence should be determined by actual observation. The opening of such areas by date instead of observation of existing temperatures would be unsafe.

---

[1] See Wells, Reprint 351 from Public Health Reports.

ATLANTIC COAST OF NEW JERSEY.[1]

Almost the entire coast of New Jersey from Sandy Hook to Cape May consists of narrow, low-lying, sandy islands or beaches, separated from the mainland by wide areas of marshes and by shallow bays or sounds connected with each other by intricate and tortuous thoroughfares, and with the Atlantic Ocean by inlets which break through the beach at irregular intervals.

The whole beach is occupied by a succession of seaside resorts, which vary in size from such a great community as Atlantic City to small groups of summer cottages. Since the principal attraction of these resorts is the ocean beach, the almost universal custom is to discharge sewage and other wastes into the thoroughfares or bays.

There are few rivers of large size which discharge into these waters, and the salinity of the water is such that conditions are extremely favorable for the growth of oysters and other shellfish—especially the hard clam, or quahog, and soft clam. Notwithstanding this, however, the oyster industry on this coast has apparently declined in recent years, and many areas formerly occupied were found barren and abandoned.

FROM CAPE MAY TO ATLANTIC CITY.

COLD SPRING HARBOR.

Proceeding up the coast from Cape May, the southern extremity of New Jersey, the first body of water encountered is Cold Spring Harbor. The only community of any size in this neighborhood is Cape May City, which is a summer resort with a winter population of 2,471 and a summer population of about 12,000. Formerly the sewage from a part of the city was discharged into Cape Island Creek, which is a tributary of Cold Spring Harbor; but recently extensive additions to the city have been laid out, which are furnished with a complete sewerage system. While about 65 per cent of the sewage from the entire city is collected at one point and pumped into Delaware Bay near the Bay Shore Life Saving Station, the remaining 35 per cent still goes untreated into Cape Island Creek. There are no records, but it is estimated by the city engineer that about 95 per cent of the houses are connected to the sewerage system.

Cold Spring Harbor has recently been dredged and the oyster beds appear to have been destroyed. At present there are few oysters or clams taken from it. Oysters known as "Cape May Salts" are unfreshened oysters from any of the near-by waters.

[1] See Tables N, O, and P, (pp. 105, 107. and 108).

JARVIS SOUND.

Jarvis Sound is just north of Cold Spring Harbor, with which it is connected by a part of the inland waterway. Formerly the seat of an important oyster industry, the beds now appear to be abandoned and covered with "sea cabbage." Samples of water showed no evidence of pollution, and there are no sources of pollution nearby.

TAYLOR SOUND.

Taylor Sound is a smaller shallow area lying northwest of Jarvis Sound and nearly opposite Turtle Gut Inlet, which opens to the ocean. There are rather extensive private beds in this sound, and the sanitary survey and examinations of oysters and water showed no danger from pollution. A sample of oysters in this area scored 2. One sample of clams taken in Swan Channel, a part of the inland waterway which connects Taylor Sound with the inlet, scored 1.

VICINITY OF FIVE MILE BEACH.

Just north of Turtle Gut Inlet and between this inlet and Hereford Inlet is an island known as "Five Mile Beach," on which are the resorts known as Wildwood Crest, Holly Beach, Wildwood, North Wildwood, and Anglesea. These towns form one continuous community which occupies practically the whole beach. The total winter population in 1910 was 3,735, but there has been a rapid increase in the permanent population, which now approximates 8,000.

This is the most popular summer resort for transients south of Atlantic City, the number of excursionists having been as high as 70,000 in a single day. These communities all have complete sewerage systems, with several separate outlets into Post Creek, Grassy Sound, and Beach Thoroughfare. It is estimated that there are about 4,300 sewer connections. At present none of the sewage is treated, but several disposal systems are under consideration.

About 25 or 30 houses along Post Creek and Grassy Sound Channel have overhanging privies. There is a small private oyster bed within a few hundred feet of the large sewer outlet under the wagon bridge at Wildwood, and the State health department has very wisely ordered that it be no longer used. Oysters from this bed are liable to dangerous pollution.

Of 10 samples of water taken by us in Grassy Sound Channel all gave *B. coli*, confirmed, in 1 c. c., and 7 in 0.1 c. c. Of 10 samples taken in Grassy Sound, 7 gave *B. coli* in 1 c. c., 4 in 0.1 c. c., and 1 in 0.01 c. c. It was not considered necessary to secure samples in Post Creek, which is clearly heavily polluted.

Conclusions.—In view of the large amount of untreated sewage discharged into Grassy Sound Channel and Grassy Sound, the shellfish

areas in this vicinity are unsafe. Few shellfish are shipped from the areas, but large quantities are consumed by visitors who come from all parts of the country. The conditions are worse in the summer because of both the increased quantity of sewage and the increased physiological activities of shellfish.

RICHARDSON BAY.

Richardson Bay is a shallow body of water connected with Turtle Gut Inlet by Richardson Channel and with Grassy Sound Channel by several narrow guts. There are no sources of pollution in this neighborhood and no oysters were found. Clams are taken from this locality in considerable quantities.

JENKINS SOUND.

Jenkins Sound lies opposite Hereford Inlet and receives water through several channels. A sample of oysters from this area scored 2. Of 10 samples of water, all were negative for *B. coli* in 1 c. c., the largest quantity planted. There are considerable quantities of shellfish shipped from this sound, which is free from pollution.

GREAT SOUND AND VICINITY.

Great Sound is a large shallow body of water opening into Hereford Inlet through Great Channel, the opening being about 3 miles above Stone Harbor.

Stites Sound and Townsend Sound are connected with the ocean by South Channel and Main Channel, which open into Townsend Inlet. All of these bodies of water are free from dangerous pollution.

The principal sources of pollution are Stone Harbor, Peermont, and Avalon, resorts on the beach between Hereford Inlet to the south and Townsend Inlet to the north.

Stone Harbor has a permanent population of 1,200, which is much augmented during the summer by cottagers. There is a complete sewerage system, owned by a corporation, to which there are connected 375 houses, practically all on the town site. The sewage is treated in two plants by sedimentation and disinfection with hypochlorite of lime before being discharged into Great Channel, which leads from Hereford Inlet to Great Sound. The disposal plants are efficiently operated.

Avalon and Peermont form one community of about 300 winter and 1,500 summer population. There are about 250 connections to the sewer system from Avalon and Peermont. There are about 20 houses not so connected.

Sewage from the public system enters Ingram Thoroughfare through several outlets, but a disposal plant now under construction is designed

to treat this sewage by sedimentation and disinfection before final discharge into the thoroughfare.

LUDLAM BAY AND VICINITY.

Townsend Inlet, Sea Isle City, Whale Beach, and Corson Inlet are small resorts on Ludlam Beach, which extends from Townsend Inlet to Corson Inlet, east of Ludlam Bay, and tributary thoroughfares.

Sea Isle City has a permanent population of 550 and a summer population of 5,000 to 6,000. The city is completely sewered, with 350 connections. The sewage is discharged untreated into Ludlam Thoroughfare and Bay. A disposal plant designed to treat the sewage by sedimentation and disinfection by hypochlorite of lime was constructed by the city about two years ago, but on account of litigation concerning ownership, it is not in use. Houses at Whale Beach and Corson Inlet are equipped with cesspools.

There are said to be no oysters in Ludlam Bay, which lies west of Sea Isle City and is connected with the ocean by Main Channel and Corson Inlet. Shellfish from the area will be unsafe so long as the sewage of Sea Island City is untreated.

VICINITY OF PECK BEACH.

Peck Beach has the Atlantic Ocean on the east, Great Egg Harbor on the west, and Great Egg Inlet, connecting the latter two, on the north.

Ocean City is a large resort on the north end of the beach with a winter population of 2,000 and a summer population at times approximating 30,000. There is a complete sewerage system with 1,800 connections and a disposal plant which consists of a septic tank and disinfection with hypochlorite of lime. The effluent is discharged into Great Egg Harbor near the inlet. There are clam beds in the immediate vicinity of the disposal plant outfall and men were observed clamming there. Despite the dilution and the previous treatment of the sewage, the taking of clams from the immediate vicinity of the outfall should be prohibited. The Annual Report of the State Board of Health of New Jersey for 1910 (p. 128) contains the account of an investigation of an outbreak of typhoid fever apparently due to the ingestion of raw clams taken from the vicinity of a sewer in Ocean City.[1]

Somers Point is a community on Great Egg Harbor on the mainland opposite Ocean City. There are no sewers except one or two from private places.

The shellfish industry here is an important one. Clams are shipped by one dealer who stores them in a pen without "drinking." Large quantities of oysters are grown in the southwestern section of the

[1] See Appendix III, p. 143.

harbor and carried to English Creek, where the water is of less salinity, to be shipped at once or after "drinking."

There are no houses on or near English Creek and sanitary conditions are excellent both there and over the oyster beds.

VICINITY OF ATLANTIC CITY.

Between Great Egg Inlet on the south and Absecon Inlet to the north lies an island or section of "The Beach" about 8 miles long, on which is the greatest seaside resort in America. Beach Thoroughfare, that portion of the inland waterway which separates this island from the mainland marshes, connects Great Egg Inlet and Absecon Inlet. Longport, Margate City, Ventnor, and Atlantic City are four municipalities which together are generally included under the one name, Atlantic City.

The combined permanent population of this community exceeds 50,000, while the transient population at times augments this number to 300,000 or even more.

Longport borough, on Great Egg Inlet, Risley Channel, and the ocean, has a complete sewerage system to which every house in the town is connected. There are two disposal plants for sedimentation and treatment with hypochlorite of lime, the final effluent being discharged into Risley Channel.

Margate City, immediately to the north, also has complete connections to a sewerage system with two plants similar to those of Longport, the effluents from which are discharged into Beach Thoroughfare.

Ventnor, between Margate and Atlantic City, has a complete sewer system with about 907 connections. The sewage was formerly treated in two small plants similar to those previously described, the effluent having been discharged into the "Inside Thoroughfare." There is now being constructed on the marsh of Beach Thoroughfare, about 2 miles from the city, a disposal plant, which consists of coarse screens, Imhoff tanks, liquid chlorine disinfection apparatus and tidal storage chambers.

Atlantic City has a complete sewerage system owned by a private corporation and practically every house, about 7,000, is connected with the 70 miles of sewers. The sewage from the main section of the city flows to a storage basin at Baltic Avenue, from which it is pumped untreated to Beach Thoroughfare, about 3 miles from Absecon Inlet.

A disposal plant in which the sewage is to pass through three sets of screens, the openings ranging from $\frac{1}{2}$ to $\frac{1}{40}$ of an inch, and be treated with liquid chlorine, is under construction.

That small district of Atlantic City known as Chelsea is served by a disposal plant which consists of equipment for sedimentation and

disinfection with hypochlorite of lime, the effluent being discharged into the "Inside Thoroughfare," a narrow blind waterway which runs, a few squares behind the ocean beach, from Margate, about 4 miles southward to Beach Thoroughfare, behind Atlantic City; this waterway is only 200 to 300 feet wide and many houses overhang the bank of the stream on the side next to the city. A mile below its head Ventnor Channel stretches at a right angle to Beach Thoroughfare, near Lake Bay.

Besides the waterways described there are many other tortuous creeks and "guts" in the marshes behind Atlantic City.

There appear to be few if any oysters growing within this area, which, however, seems to be very prolific of clams, both hard and soft; and during the summer season many are taken from the area for local consumption, as well as for fish bait.

The State department of health, as a result of an examination of shellfish and water from this area, has defined limits within which "the taking of oysters, clams and other shellfish from these waters or having in possession with intent to distribute or sell them" is prohibited.

Dr. Guion, for years the city health officer of Atlantic City, reported (Proceedings Thirtieth Annual Meeting of the New Jersey Sanitary Association) that in 1903 there were 75,500 bushels of oysters and 3,820,000 clams consumed in Atlantic City. There were 20,000 bushels of oysters and 5,240,000 clams shipped to other points. Most of this product was brought in by boat from local waters within a radius of 10 miles; 87,000 bushels of oysters and 8,915,000 clams having been thus obtained. The remainder of the total yearly traffic was shipped in by rail, and 60 per cent of the oysters and 70 per cent of the clams are handled in the seven warm months of the year. He states: "The original source of these oysters are unpolluted; 25,000 bushels come from Eagle and Grassy Bays, 14,000 bushels from Absecon and Lake Bays, and 53,000 bushels from Great Bay."

The prohibited area is: Beach Thoroughfare from its mouth at Absecon Inlet to the Boulevard Bridge; Great Thoroughfare to the Boulevard Bridge over that water; all of "Inside Thoroughfare;" all of Ventnor Canal; all of Clam Creek and its tributaries; and all of Clam Thoroughfare. As a result of the Public Health Service investigation the action of the State department is thoroughly approved and the location of the limits are believed to have been judiciously selected. In one or two instances during this investigation men were found taking clams which they asserted were to be used as bait. It is believed that some clams are still taken and sold for food, but the quantity is probably small.

The importance of eliminating every factor in the spread of infectious diseases is obvious, in addition to which the enormous amount

of money invested in hotels and boarding houses in Atlantic City is so much greater than the value of the shellfish industry that the latter hardly need be considered, and there is every reason to hope that energetic police measures will be continued toward eliminating the danger of infectious disease through the taking of shellfish from this area. Several years ago a small outbreak of typhoid fever occurred which was thought to have been caused by eating shellfish from the heavily polluted waters near the sewer outfall. This outbreak was investigated by Snow, Guion, and others and a comprehensive report made.

LAKE BAY.

Lake Bay is a body of water about 3 miles inland from Atlantic City. To the northeast it receives Great Thoroughfare, which is about 3 miles long, and joins Beach Thoroughfare behind Atlantic City. To the southeast Beach Thoroughfare is merged into Lake Bay by an area known as Shelter Bay. Most of the tidal flow is by way of Beach Thoroughfare and Risley Channel to Great Egg Inlet.

Pleasantville is a town with 4,390 population on the mainland or west side of Lake Bay. The town has no sewers. The shellfish industry is a large one, engaging about 150 persons. It is believed that no sewage from Atlantic City ever reaches this water and a sample of oyster taken from beds nearest Great Thoroughfare and Ventnor Canal gave a score of only 1. Of 5 samples of water taken in the open area, all were negative for *B. coli* in 1 c. c., the largest quantity tested.

A large part of the oyster industry consists in removing the shellfish from their layings to long artificial ditches which have been dug up into marshy areas adjoining Pleasantville. The salinity of the tidal water in these drains is considerably reduced on ebb tide by the fresh water which seeps from the marshes and from small streams or ditches which extend a half mile or so inland. Oysters are left on platforms on the bottoms, covered by sheds, for one or more tides for the purpose of cleansing and "drinking," during which process their bulk is increased and salinity lessened. All oysters are shipped in the shell and the market extends to many inland cities of Pennsylvania. Three of these creeks were being used at the time of this inspection. One sample of oysters was taken from each "drinking" place—one of which gave a score of 4, and the others 0.

Of 15 water samples 9 were positive in 1 c. c. and 4 in 0.1 c. c. Within 25 or 30 feet from the eastern or Mathis oyster house there was an open-surface privy, which constitutes a constant menace to oysters floated in the near-by ditch. In addition to this menace it is believed that drainage from a large steam laundry enters the stream. This ditch will be a constant danger, and proper authority should cause the immediate removal of the privy. Attention of the State

board of health was directed to the condition. The other ditches and houses were in good sanitary condition.

A sewer carrying the waste water only from the Risley Laundry empties into a creek, about one-half mile from Lake Bay, the creek discharging within a few hundred feet from the oyster area. It was stated at the laundry that no sanitary sewage reached this drain, the employees using a sanitary toilet provided for them.

ABOVE LAKE BAY.

ABSECON BAY.

Absecon Bay lies north of Lake Bay and is connected with the ocean by Main Channel and Absecon Inlet. A small creek called Absecon Creek, fed by springs and by surplus water from the Atlantic City Water Works near by, enters the bay from the west. Along the creek lies the village of Absecon; below, along the marshy bank of the creek, are four or five oyster shipping houses, in front of each of which are one or more oyster floats, in which oysters from the layings in the bay are kept for "drinking" and convenience in shipping.

A close inspection of the creek revealed no source of pollution of any sort except a storm sewer draining a portion of the village streets, and an open, dirty, surface privy within 25 feet of the lowest oyster house.

Of 10 samples of water taken in the creek only one was positive for *B. coli* in 1 c. c.

Of three samples of oysters taken from the floats one gave a score of 0, one a score of 1, and one a score of 2. Two samples taken from the bay gave scores of 0 and 2, respectively. The attention of the State board of health was directed to the privy.

GREAT BAY.

Great Bay is a shallow body of water about $3\frac{1}{2}$ miles in diameter, lying north of Absecon and west of Little Egg Inlet, by which it is connected with the ocean. It has a depth of from 4 to 13 feet. There are no communities on the bay. Mullica River empties into the western end of Great Bay. This river is three-fourths mile wide at its mouth and one-third mile wide 6 miles above. Extensive seed beds are found near its mouth. There are no sources of considerable pollution on either the bay or river.

LITTLE EGG HARBOR.[1]

Little Egg Harbor is located east of Tuckerton and is bounded on the ocean side by Long Beach; it is connected with Great Bay and extends north to Manahawken Bay.

[1] See Table O, (p. 107).

Beach Haven Borough is a summer resort with a normal population of 272. The community has recently installed a sewage-disposal system, the effluent from which is discharged into the ocean. Several restaurants and hotels not connected therewith are said to discharge sewage into the bay. This resort is closed during the winter season.

The only other communities on the bay are Tuckerton and West Creek, the latter being a hamlet without sewerage system.

Tuckerton is a borough with a population (1910) of 1,868, and has a considerable trade in oysters, clams, and fish. Oyster beds are located along the eastern shore of Little Egg Harbor north of Tuckerton Creek, in the thoroughfares connecting Great Bay with Little Egg Harbor, and in the vicinity of Beach Haven.

This area was inspected by the Public Health Service during cold weather, but it is stated that during the summer months 12 or 15 house boats anchor within 500 feet of the beds near Beach Haven. Previous to 1913 oysters were floated in dangerous proximity to the outfalls from Beach Haven hotels, but it is stated that this practice has been stopped by action of the New Jersey State Board of Health.

On an island near the center of the bay is a fish rendering factory, which employs about 75 men from May to November. The nearest oyster beds are about 1 mile from this island. The State board of health found that of 28 samples of water taken in the bay, only 7 per cent, or 2 samples, showed gas in 1 c. c. quantities.

Oysters taken in Little Egg Harbor are removed from the beds to Tuckerton Creek, West Creek, Big Creek, Mullica and Bass Rivers, and there "floated" before they are shipped.

TUCKERTON CREEK.

Tuckerton Creek rises in Cedar Swamps above Tuckerton and is dammed at Tuckerton for the water supply of the town. The stream is tidal for about $2\frac{1}{2}$ miles below the dam. Careful search failed to show any source of pollution other than an occasional house boat. The oyster floats are secured alongside the bank, the uppermost float being about one-half mile below the dam, and they extend for about 1 mile below the town.

The town has no public sewerage system and no private sewers empty into the creek. No privies or other sources of pollution were found near the floats.

Of five samples of water taken from the dam down to the floats, three showed *B. coli* present in 10 c. c., but not in 1 c. c.; and two in 1 c. c. quantities, but not in 0.1 c. c. The oysters were examined 48 hours after they were taken from the water; of ten samples, one scored 32 and two 23, the others all scoring 14 or less. Oysters from

Tuckerton Creek are believed to be safe, so long as the board of health continues its present efficient supervision. There is some potential danger in every creek of this character.

WEST CREEK.

West Creek is similar to Tuckerton Creek and there are no sources of pollution on its banks. One sample of water from a tributary showed *B. coli* present in 0.1 c. c. It drained a field and there was no other apparent source of pollution. Oysters all scored 3 or less; the temperature, however, was nearly 0° C. when they were taken.

BARNEGAT BAY.[1]

Barnegat Bay is a large, shallow body of water extending from Barnegat Inlet 18½ miles northward on the west side of Island Beach to Bayhead and about 4 miles westward to the village of Barnegat; here it connects with shallow estuaries extending southward 15 miles back of Long Beach to Little Egg Inlet. In the bay are numerous islands and flats, and a large number of creeks and small rivers discharge into it from the west.

The principal villages on the bay and its tributaries and their distances from Barnegat Light House are as follows: Waretown, 4 miles; Barnegat, 5 miles; Forked River, 6½ miles; Cedar Creek, 8½ miles; Toms River, 15 miles; Bayhead, 18½ miles.

Until recent years the shellfish industry of this area was an extensive one. Oysters were grown in the numerous thoroughfares and "guts" and were floated in various small streams in the neighborhood. At present the industry is small, and only a few bushels of "shell stock" are shipped daily during the season.

Samples were obtained on December 14, in Barnegat Creek, a small stream near Barnegat, with the following results: One sample scored 3, two scored 2, and two scored 0. So far as could be ascertained there is no pollution in the creek.

During the summer season the clam industry engages the partial or entire time of hundreds of persons in this section.

It is believed that these shellfish as a whole are entirely safe. None of the towns except Beach Haven have sewerage systems, the immediate dilution is very great, and the area of probable pollution small. Unless the shellfish be gathered in the immediate vicinity of local sources of pollution they are quite free from danger.

There is no shellfish industry of consequence above this area until the northern end of the New Jersey coast is reached at Sandy Hook. The conditions in this section have been discussed in connection with Raritan Bay.

---

[1]See Table P (p. 168).

SUMMARY AND CONCLUSIONS.

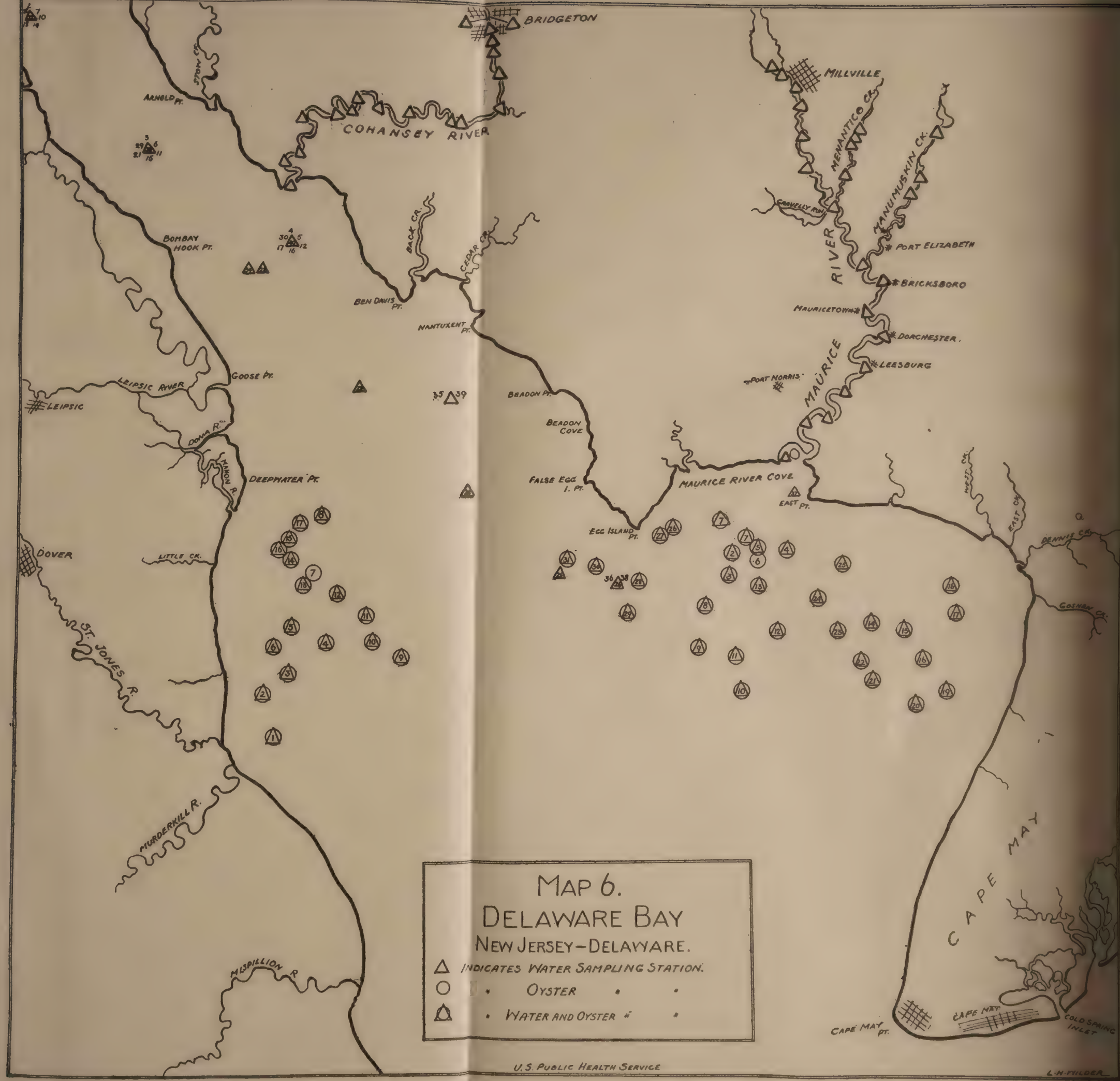
The oyster industry along the New Jersey Coast is at present declining and is of comparatively little importance. The clam industry is important both economically and from a sanitary point of view, because these shellfish are, for the most part, gathered during the period of greatest danger of infectious pollution. Owing to the fact that the population is enormously augmented during the summer season, the incidence of typhoid fever is then greatest, and it is also the period of increased physiological activity of the shellfish.

The majority of the resort communities have more or less efficient sewage disposal plants, the effluents from which are discharged into large bodies of tidal waters, and the enormous dilution and restricted area of movements of such waters form a very great safeguard.

A thorough enforcement of the present State regulations against the taking of shellfish from the condemned areas around Atlantic City and Wildwood, the closure of flats in the vicinity of sewer outfalls such as those at Ocean City, and the abolition of such obvious dangers as the privies in the Mathis "drinking" ditch at Pleasantville and the Conover privy at Absecon, are very essential but should not be difficult.

Large numbers of clams are gathered by summer visitors for their own consumption, and the use of publicity to educate such persons as to the dangers to be avoided impress us as being important.

The question of the pollution of bathing beaches is an important one along this coast, but no instances of gross pollution of important beaches were noted. The prevention of bathing in the immediate vicinity of outfalls along thoroughfares and inland waters is rather difficult and appears to be a matter for education and local police regulations.



MAP 6.
DELAWARE BAY
NEW JERSEY—DELAWARE.

△ INDICATES WATER SAMPLING STATION.
○ " " OYSTER " "
△ " " WATER AND OYSTER " "

U. S. PUBLIC HEALTH SERVICE

L. H. WILDER

DELAWARE BAY AREAS.

There are extensive and valuable oyster beds on both sides of Delaware Bay from about Bombay Hook down to within a few miles of the mouth of the bay. The upper area from the above point down to near a line from Mahon River eastward across to Ship John Light is very prolific; oysters grow very rapidly and the natural beds of this area are the source of most of the seed oysters used in planting the area below the line, both in Maurice River Cove and on the Delaware side of the bay.[1]

The bay is an expansion of the lower part of Delaware River, the dividing line being from Bombay Hook Point to Cohansey Light House. The entrance to the bay from the ocean, between Cape May on the north and Cape Henlopen on the south, is 10 miles wide; but as shoals extend $6\frac{3}{4}$ miles south and southwest from Cape May, the deep channel is less than 4 miles in width. The bay is of irregular shape, its greatest dimension in a generally NNW. and SSE. direction being 32 miles; at its northern extremity, between Bombay Hook Point and Cohansey Lighthouse, it is $3\frac{3}{4}$ miles wide, but just below Egg Island Point it has a width of 24 miles.

Extensive shoals, with depths varying from 4 to 18 feet, occupy a greater part of the bay, but there is a deep and well-marked channel leading to the entrance of Delaware River. From Cape May the eastern shore extends about 13 miles in a general NNE. direction to the mouth of Goshen Creek. Here the shore turns northward and westward and trends in the latter direction for about 7 miles to East Point, on which is situated Maurice River Lighthouse. The bight thus formed and the northern part of the bay in its vicinity is known as Maurice River Cove, into the northeastern part of which, about 1 mile northward of East Point, Maurice River discharges.

DELAWARE RIVER.

SANITARY SURVEY.

Sources of pollution.—The Delaware River rises in the southern part of the State of New York and flows in a general southerly direction for about 250 miles to its junction with Delaware Bay, forming the boundary between the State of Pennsylvania and the States of New York and New Jersey. The city of Trenton, 114 miles above the

[1] See map No. 6.

head of the bay, is the head of navigation, below which point the river is subject to tidal influence. The banks of the river are mostly low and in many places marshes extend some distance back from them. There are numerous large and small communities which contribute pollution directly into the stream, the most important of which are:

TABLE 6.—*Important cities on tidal portion of Delaware River.*[1]

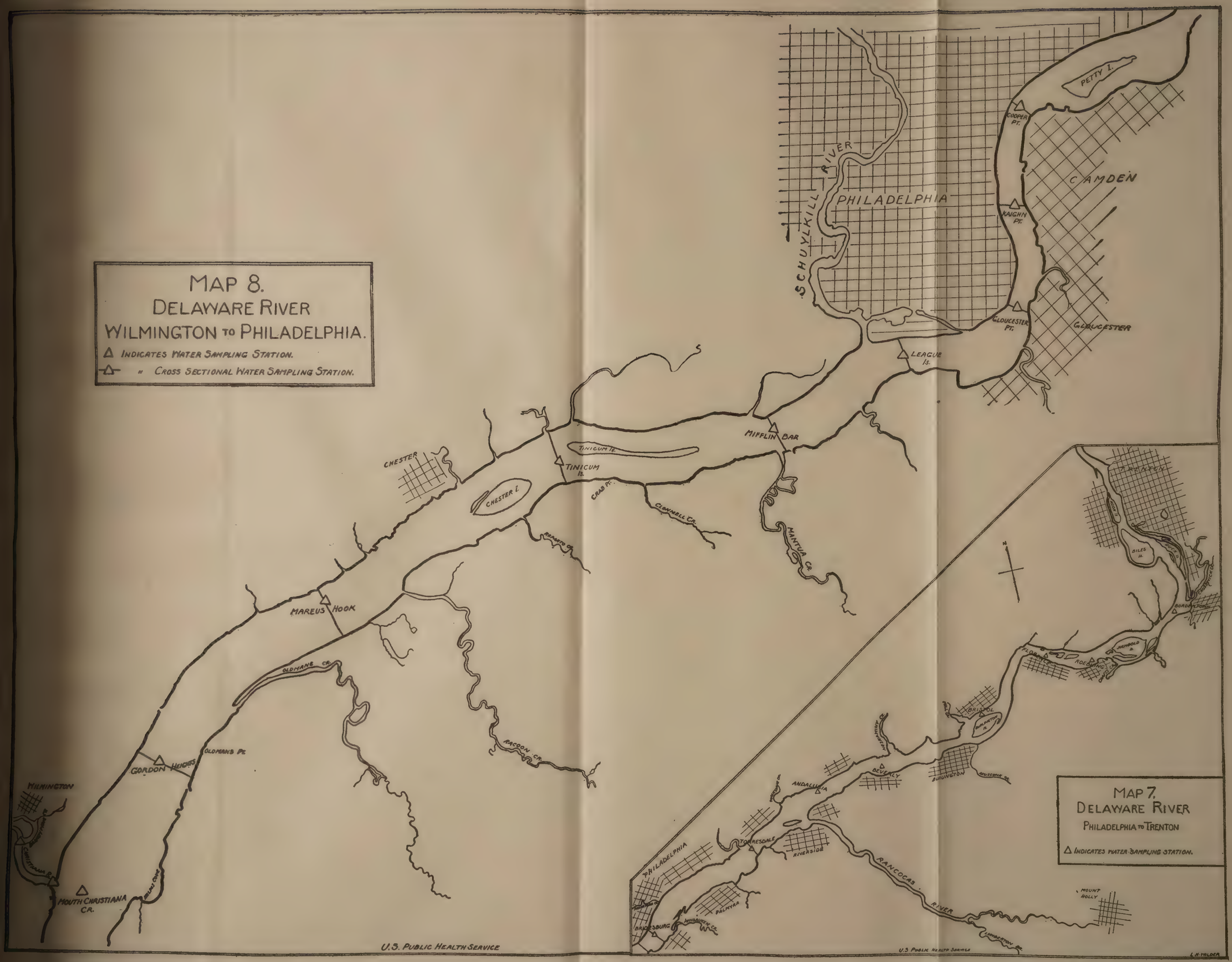
Place.	Distance in miles above head of bay.	Population.
Trenton	82	[2] 109,212
Bordentown	75	4,250
Camden	54	[2] 104,349
Philadelphia	54	[2] 1,683,664
Chester	43	[3] 38,537
Wilmington	32	[3] 87,411
Penns Grove	33	[4] 20,000
New Castle	27	[3] 3,351
Delaware City	23	[3] 1,152
		2,051,926

[1] See maps 7, 8, and 9.
[2] Based on U. S. Census as of 1915.
[3] Census 1910.
[4] Estimated.

The banks of the river have many additional sources of industrial and domestic sewage.

The most important tributaries adding pollution to the river are: Lehigh River, which discharges into the Delaware above Trenton after receiving a large amount of mine wastes and sewage from Allentown, Bethlehem, South Bethlehem, Easton, and other communities in Pennsylvania, with a total population of over 100,000, and Phillipsburg, N. J., with a population of about 14,000. The Schuylkill River discharges into the Delaware at Philadelphia after receiving large quantities of mine and other wastes and sewage from the cities of Reading, Pottstown, Phoenixville, Norristown, and other communities above Philadelphia, together with much sewage from Philadelphia. Christiana Creek receives the sewage of Wilmington, situated on its banks, 1 mile from the point at which the creek enters into Delaware River, 32 miles above the head of the bay.

On account of the lack of sufficient time and force, it was impracticable to make a sanitary survey of the tributaries or of the river itself. However, an approximate idea of the amount of domestic sewage contributed to the stream may be estimated from population statistics given above. It should be remembered, moreover, that in addition to these large communities, the watershed in the immediate vicinity of the river contains a large population, both urban and rural. There are few streams in the United States which receive industrial wastes larger in amount and more diverse in character. An intensive



69263°–17. (To face page 54.)

MAP 8.

WILMINGTON
BRANDYWINE R.
CHRISTIANA RIVER
MOUTH CHRISTIANA CR.
WHITE CLAY CR.
PIGEON PT.
PIGEON PT.
SALEM CANAL
NEW CASTLE
NEW CASTLE
ARMSTRONG CR.
PENNS NECK
RIVER
RED LION CR.
SALEM
PEA PATCH I.
DELAWARE CITY
DELAWARE CITY
SALEM COVE
CHESAPEAKE AND DELAWARE CANAL
REEDY PT.
REEDY ISLAND
ELSINGBOROUGH PT.
REEDY I.
REEDY ISLAND
ALLOWAY CR.
ST. AUGUSTINE CR.
STONEY POINT SHOAL
HOPE CR.
STONY PT.
APPOQUINIMINK CR.
STONY POINT SHOAL
BLACKBIRD CR.
ALDER COVE
MAD HORSE CR.
LISTON PT.
LISTON POINT
DELAWARE PT.
SMYRNA RIVER
BOMBAY HOOK
ARNOLD SHOAL BUOY

MAP 9.
DELAWARE RIVER
BOMBAY HOOK TO WILMINGTON.

△ INDICATES WATER SAMPLING STATION.

⊣△⊢ " CROSS SECTIONAL WATER SAMPLING STATION.

U. S. PUBLIC HEALTH SERVICE

L. H. WILDER

69263°–17. (To face page 54.)

study of the pollution and self-purification of this river should be undertaken in the near future by this Service.

Tides and currents.—It was evident from the writer's experience with other tidal streams that it would be impracticable, with the available force and time, to determine by actual experiment the time factor in the purification of the river between the sources of pollution and the oyster beds. However, an approximate estimate of the average downward gain per day under conditions of normal stream flow may be determined from the data already at hand.

The accompanying table (No. 7) taken from U. S. Coast Pilot, Part V (U. S. Coast and Geodetic Survey), shows the velocities of tidal currents in the river.

TABLE No. 7.—*Velocity of tidal currents in Delaware River.*

	Locality of station.					
	Off New Castle, Del.[1]		Philadelphia, Pa., off Chestnut Street Pier.		Philadelphia, Pa., foot of Petty Island.[2]	
	True direction of current.	Velocity.	True direction of current.	Velocity.	True direction of current.	Velocity.
	Degrees.	*Miles.*	*Degrees.*	*Miles.*	*Degrees.*	*Miles.*
Hours before high water at Philadelphia 2	247	1.79	200	1.4	242	1.76
Hours before high water at Philadelphia 1	285	.68	200	1.3	238	1.66
Hours before high water at Philadelphia 0	29	.94	200	.9	233	1.19
Hours after high water at Philadelphia 1	42	1.68	.....	.0	222	.44
Hours after high water at Philadelphia 2	46	1.91	358	1.1	51	1.12
Hours after high water at Philadelphia 3	48	1.91	358	1.4	48	1.49
Hours before low water at Philadelphia 2	50	.73	358	1.2	51	1.65
Hours before low water at Philadelphia 1	240	1.23	358	1.1	52	1.46
Hours before low water at Philadelphia 0	246	2.20	358	.8	48	.87
Hours after low water at Philadelphia 1	248	2.60	200	.7	234	1.15
Hours after low water at Philadelphia 2	247	2.36	200	1.2	239	1.66
Hours after low water at Philadelphia 3	251	1.58	200	1.4	240	1.78

[1] Observations made in month of August.

[2] Observations made in month of July.

From data contained in the foregoing table and the Atlantic Coast Tide Tables, 1916 (U. S. Coast and Geodetic Survey), the following deductions have been made:

Average net gain downstream a day at Chestnut Street Wharf, Philadelphia:

Average duration of ebb tide, 7.23 hours.
Average velocity of ebb tide, 1.12 miles an hour.
Average of miles traveled on ebb tide, 8.09 or 16.2 miles a day.
Average duration of flood tide, 5.17 hours.
Average velocity of flood tide, 1.15 miles an hour.
Average of miles traveled on flood tide, 5.95 or 11.9 miles a day.
Average net gain downstream a day, 4.3 miles.

Average net gain downstream a day at New Castle, Del.:

Average duration of ebb tide, 6.9 hours.
Average velocity of ebb tide, 1.61 miles an hour.

Average of miles traveled on ebb time, 11.10 or 22.2 miles a day.
Average duration of flood tide, 5.50 hours.
Average velocity of flood tide, 1.66 miles an hour.
Average of miles traveled on flood tide, 9.13 miles an hour, or 18.3 miles a day.
Average net gain downstream a day, 3.9 miles.

The distance between Philadelphia and the upper limits of the market oyster beds is about 60 to 65 miles; therefore, even if we reckon only on constantly suspended particles such as free bacteria probably are, the time interval between Philadelphia and the oyster beds may be estimated roughly at from 12 to 15 days, depending upon stream flow and winds. For substances not in solution or of greater specific gravity than water the time factor is far greater.

From Wilmington, the nearest source of large pollution to the same beds, the distance is about 40 miles. The average down gain a day at New Castle, just below Wilmington, is about 4 miles, and this section would be less subject to the effect of variations due to stream flow. However, as the river gradually becomes wider below Newcastle the net down gain must be much less than the above.

Dilution.—No calculations as to the amount of water in the tidal prism at any point are available, but the quantity of unpolluted ocean water which goes into the lower reaches of the bay and river is enormous.

BACTERIOLOGICAL AND DISSOLVED OXYGEN RESULTS.

For the purpose of determining the extent of pollution in the river and what effect, if any, such pollution might have on the sanitary condition of the water over the areas where oysters are grown in the bay, 211 samples of water were taken on the river for bacteriological examination and 284 dissolved oxygen determinations were made; 134 samples of water and 48 samples of oysters were collected from oyster areas and other points in the bay over a period extending from August to December, 1915, inclusive.[1]

The samples from the river were taken at various stations from Bordentown at the entrance to the D. & R. Canal, 21 miles above Philadelphia, to the junction with the bay at Bombay Hook Point. Eleven of these stations were chosen for cross-section studies, including the dissolved oxygen determinations, the first being at Torresdale and the last at Reedy Island. These points were selected with reference to sources of pollution and were spaced as regularly as this arrangement permitted, with the idea of ascertaining the extent of self-purification going on, the effect of additional pollutions, and the point at which the stream recovers itself.[2]

[1] See Tables Q, R, S, and T, (pp. 109–120).
For location of sampling stations see maps 8, 9, 10.

The results of these studies are shown in detail in Tables Q, R, S, and T, an analysis of which is given in Table U, and the results for the cross sections have, in addition, been plotted on Chart No. 2, for the purpose of showing graphically the extent of pollution and the dissolved oxygen content over the entire area by the cross sections.

From Bordentown down to Torresdale the river seems to have a fairly uniform *B. coli* content, practically all samples being positive in 0.1 c. c. quantities, and there was no serious departure from the normal in free oxygen present.

A slight increase in *B. coli* and decrease in oxygen was noticed from Torresdale to Bridesburg. The latter place is near the entrance of the heavily polluted Frankford Creek and roughly marks the upper limit of the flood tidal effects from the city.

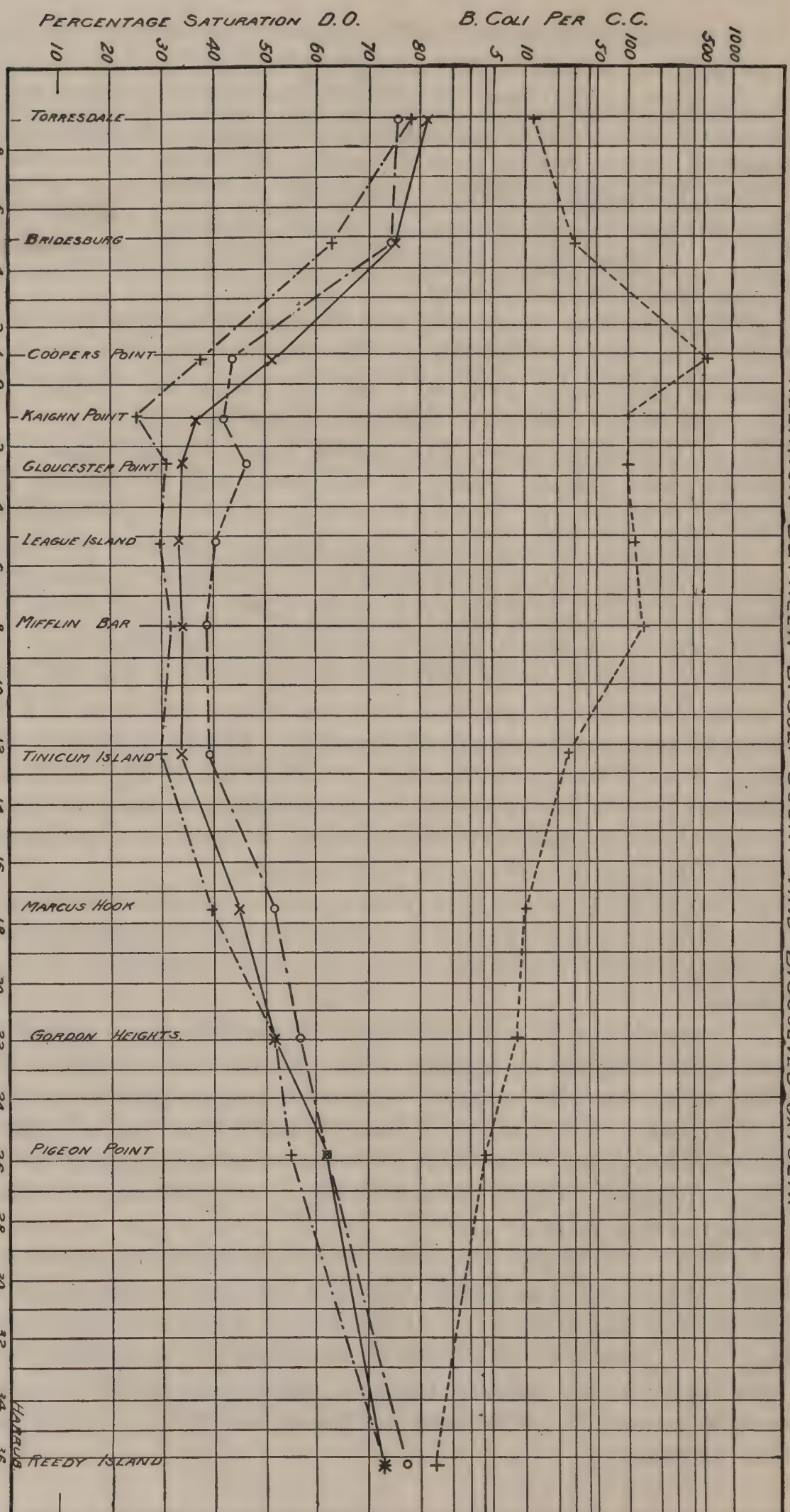
From Bridesburg down to Coopers Point, at the upper end of Camden, and Kaighn Point, at the lower end of Camden (both opposite Philadelphia), there was a sharp rise in *B. coli* content and a corresponding though somewhat lagging decrease in dissolved oxygen content. This whole section is constantly receiving additional pollution from both sides of the river, and just below Philadelphia there is a heavy influx from the Schuylkill River.

This is the last heavy pollution in this section and the *B. coli* content immediately begins a decrease, which continues in a fairly constant ratio to the mouth of the river. The large amount of pollution from Wilmington entering the Delaware at Pigeon Point has little apparent effect upon the *B. coli* or oxygen content of the river, despite the heavy pollution of Christiana River shown by bacteriological examinations and oxygen determinations.

As would be expected, the free-oxygen line on the chart lags considerably and recovery was not begun until Tinicum Island was reached, 7 miles below the entrance of the Schuylkill at League Island.

In general, the *B. coli* content at Torresdale above Philadelphia was again reached at Marcus Hook, about 14 miles below Philaphia, while the percentage of dissolved oxygen present at Torresdale was not recovered until Reedy Island was reached, 40 miles below Philadelphia. Even here the apparent recovery was probably due in part to dilution with sea water, the influence of which is marked at this point.

As shown by Table U, there was a gradual diminution in the bacterial content from Reedy Island, where 37 per cent of the samples gave *B. coli* in 0.1 c. c., 84 per cent in 1 c. c., and 94.7 per cent in 10 c. c. quantities, or a mean of 1.4 *B. coli* per c. c., down to Ship John Light, at the head of the bay, where only 50 per cent of the samples showed *B. coli* present in 10 c. c., and none in smaller quantities of water.



RELATION BETWEEN B. COLI COUNT AND DISSOLVED OXYGEN.

U.S. PUBLIC HEALTH SERVICE

DELAWARE BAY.

Examination of samples of oysters and water from Delaware Bay showed very little evidence of pollution, even in the upper end, from which oysters are taken for seed purposes only. Of 69 samples of water taken on the New Jersey side below Ship John Light and including Maurice River Cove, 7.2 per cent showed *B. coli* present in 1 c. c. and but 23.2 per cent present in 10 c. c.

On the Delaware side of the bay, of 34 samples, 3 per cent were positive for *B. coli* in 1 c. c. and 15 per cent in 10 c. c.

Of 31 samples of oysters taken in that section of Maurice River Cove near the mouth of the Maurice River, one scored 23 and one 14; in no other instance was the score over 5, and 17, or nearly 55 per cent, gave a score of 0. A study of tidal and weather conditions at the time the two first-mentioned samples were collected indicated that the pollution present apparently came from Maurice River.

Of 17 samples of oysters taken on the Delaware side, in no case was the *B. coli* score over 5. In this connection it should be remembered that this study extended over the period of the year in which the oyster shipping in this district is at its height and during the earlier part of which the danger of infectious pollution was probably at its maximum.

SUMMARY AND CONCLUSIONS.

1. The Delaware River, from Bordentown to Torresdale, is moderately polluted and unsafe for use as a drinking water unless subjected to suitable purification.

2. The river from Bridesburg, just above Philadelphia, down to Mifflin Bar, just below Philadelphia, is grossly polluted, as evidenced by the high bacterial content and deficiency of oxygen.

3. The bacterial content at Marcus Hook, 14 miles below Philadelphia, and the dissolved oxygen present at Reedy Island, 40 miles below that city, are approximately the same as at Torresdale.

4. From Reedy Island down to the junction of the river and bay the self-purification continues, so that at the latter point *B. coli* were found present in only 50 per cent of 10 c. c. samples.

5. Analysis of the results obtained in Delaware Bay shows an absence of serious pollution; the mean average of less than 1 *B. coli* in 50 cubic centimeters of water, with a total bacterial count at 37° of less than 50 colonies per cubic centimeter, indicate a water of considerable purity.

6. It is evident, therefore, that shellfish as taken from the beds of Delaware Bay are safe as an article of food.

MAURICE RIVER.

GENERAL OBSERVATIONS.

In view of the fact that practically all oysters grown in Delaware Bay are carried to the Maurice or Cohansey Rivers and floated in these waters before they are shipped, and because of their subsequent wide interstate distribution, an intensive study of sanitary conditions in these streams was made in cooperation with the State department of health. This investigation covered a sufficiently long period of time to include all seasonal variations.

EXTENT OF OYSTER INDUSTRY.

The oyster industry has grown to considerable size in this part of the State. Bivalve and Maurice River, the two shipping points near the mouth of the Maurice River, are reported to handle about 100 carloads of oysters daily during the busy season. The business carried on at these places amounts to several millions of dollars annually; hence serious pollution of the producing area, resulting necessarily in the condemnation of oysters from these localities, would be a matter of vital concern to these towns and to the State as a whole, while the interstate shipment of the oysters throughout the country make the sanitary conditions of these areas a matter of material importance.

METHOD OF HANDLING OYSTERS.

The oysters are grown in portions of the Delaware Bay in comparatively shallow water, the greater number of beds on the New Jersey side being in Maurice River Cove, which extends from Egg Island Point to Cape May Point. The bottom of the bay here is for the most part mud, although some parts are sandy, with a depth of water ranging from 5 to 30 feet.

Oysters are dredged from these beds, loaded on boats, and brought to the floats located along the banks of the Maurice River, the waters of which are less saline than those over the beds. The floating process consists in placing the oysters in partially submerged open scows, located in such a way that the surface water from the river passes over and around the oysters. Here the oysters, while feeding, take in a certain amount of river water, and expel grit and sand. During this process, as a result of osmosis, the bulk of the oyster is greatly increased and, to the uninitiated, the oyster appears to be

very fat. If the river water in which the oysters are floated is polluted, the floating process necessarily results in contamination of the oysters, and in many cases ultimate rejection on the market. Oysters are usually floated for two tides, or about 24 hours, although this time may be varied on account of various local conditions. During low temperatures, when the oysters are physiologically inactive, the floating is often extended over periods of several days.

Oyster floats are located on both sides of the Maurice River in what is known as the "Long Reach," about 2 miles from the mouth of the stream, and also on the Cohansey River at Greenwich Pier. When the oysters have taken in enough of the fresh river water to sufficiently reduce the salt content, increase their bulk, and rid themselves of grit, they are removed from the floats to scows, brought to the wharves, counted into barrels or sacks, and shipped. During these various handlings the oysters remain tightly closed and the chances of contamination are comparatively slight. In order, however, to reduce this chance to a minimum, considerable care is exercised in securing clean bags and barrels, and even the shipping cars are required to be satisfactorily cleaned before they are used for transportation. Both the State and local authorities are to be commended for their activity in securing good local sanitary conditions.

A very small percentage of the oysters shipped from the Maurice and Cohansey Rivers are shucked, almost the entire product being shipped in the shell, so that the possibility of contamination in the shucking process is almost entirely eliminated at these points.

NATURE OF INVESTIGATION.

From the above brief outline it is seen that the most probable sources of pollution of Maurice Cove oysters would be:

1. Contamination from the waters in which they are grown.
2. Contamination by shipping in dirty containers and cars.
3. Contamination by coming into contact with polluted river water during the floating process.

As has been previously shown, oysters taken from the beds were found to be free from any serious pollution, and the water from Maurice River Cove, over the beds, was also found to be of satisfactory quality.

The possibilities of contamination in shipping are believed to be negligible in view of the care taken to secure clean containers and cars and also because of the fact that the oysters remain closed during handling and shipment. In view of these facts it is evident that any insanitary condition of oysters shipped from these points depends upon the condition of the waters of the river in which they are floated.

SANITARY SURVEY OF MAURICE RIVER WATERSHED.

A preliminary sanitary survey of Maurice River was made in September, 1915, by Sanitary Engineer C. A. Haskins, and this was supplemented in October and November by a more comprehensive study by Sanitary Engineer J. K. Hoskins.

Maurice River, the largest stream in southern New Jersey, rises near Glassboro, in Gloucester County, and flows almost due south, about 33 miles, to Maurice River Cove, a part of Delaware Bay. The entire drainage area, as shown on the accompanying map, No. 10, comprising 405 square miles, is in the flat sandy formation common to southern New Jersey, most of which is sparsely populated, a considerable part being forested. The greater part of the drainage area lies in Cumberland County.

The river is navigable and tidal to Millville, where a large dam divides the stream into two parts, each of which will be considered separately.

I. RIVER ABOVE MILLVILLE.

The drainage area above the head of tide, comprises an area of 226 square miles, a considerable portion of which is forested. The forest drainage imparts a high vegetable color to the water, the turbidity usually remaining low. An earthen dam, 2,200 feet long, located one-half mile above Millville, impounds the river water in a reservoir with an area of 926 acres, forming the largest artificial lake in the State. A fall of 26 feet is made available by this dam, and the resulting power is used for industrial purposes.

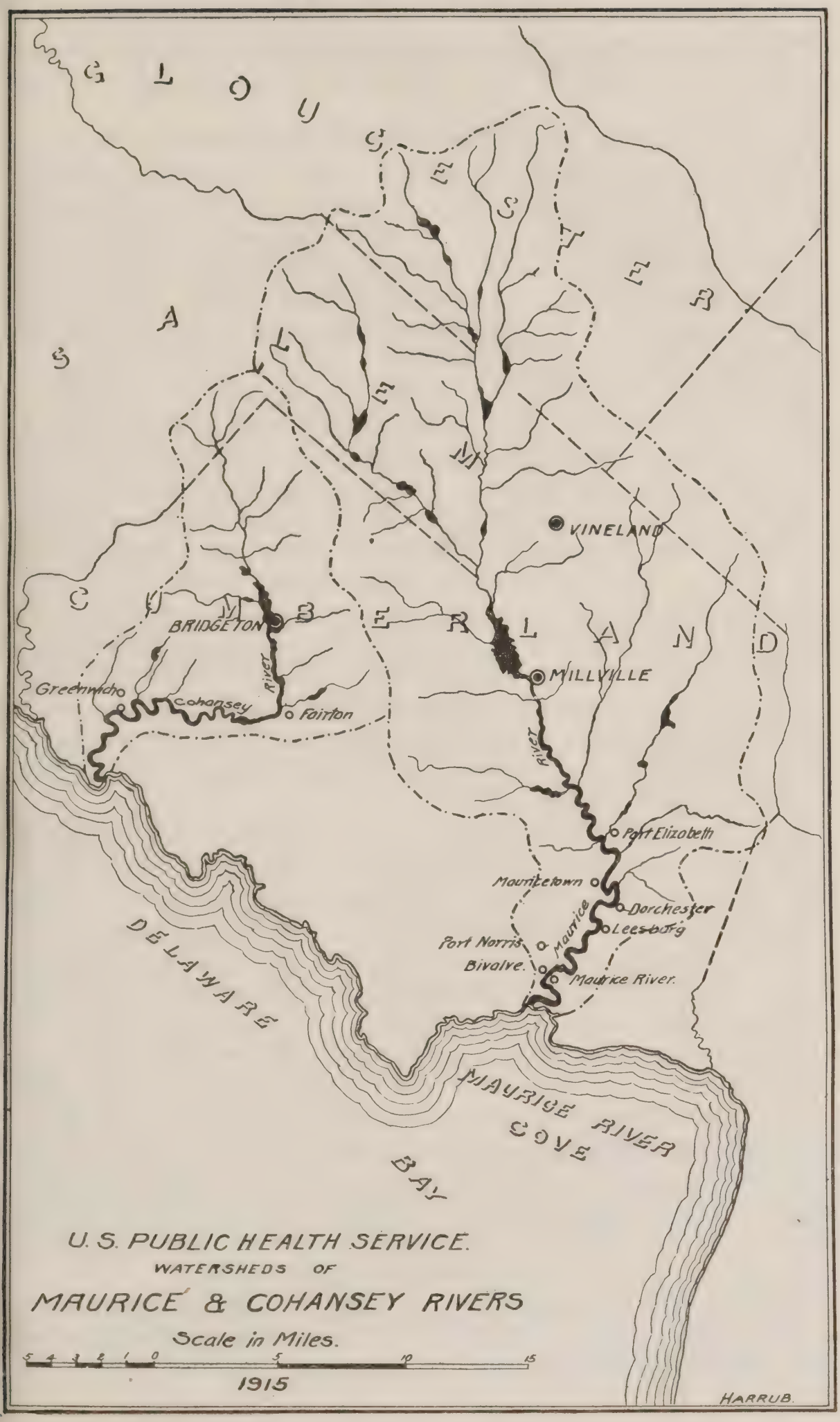
Stream flow.—Few accurate records of stream flow of the Maurice River are available. The report of Geo. W. T. Miller on the Maurice River,[1] states that the average flow at Millville is 35,300 cubic feet per minute. Volume III of the Report of the Geological Survey of New Jersey for 1894 estimates the average flow as lower than this, or about 21,800 cubic feet per minute. The average discharge during the driest year is estimated as 18,600 cubic feet per minute, while the flow during the driest month is given as 3,510 cubic feet per minute.

Population.—The largest town on this part of the watershed is Vineland, having a population in 1910 of 5,282, and in 1915 estimated at 5,760, while the 1915 State census gives about 6,200. The rural population of the watershed is estimated at 58 per square mile, giving a total rural population of about 13,100. The total population on the watershed above Millville is therefore about 19,300, or 85.5 per square mile.

Truck farming is the principal occupation of the rural population and a considerable portion of this area is under intensive cultivation.

[1] Doc. 667, 29th Congress.

MAP NO. 10.


GLOUCESTER
SALEM
CUMBERLAND
VINELAND
BRIDGETON
MILLVILLE
Greenwich
Cohansey
Fairton
Cohansey River
Maurice River
Port Elizabeth
Mauricetown
Dorchester
Leesburg
Port Norris
Bivalve
Maurice River
DELAWARE BAY
MAURICE RIVER COVE
U. S. PUBLIC HEALTH SERVICE.
WATERSHEDS OF
MAURICE & COHANSEY RIVERS
Scale in Miles.
5 4 3 2 1 0 5 10 15
1915
HARRUB.

Sources of pollution.—The principal and practically only direct source of pollution of Maurice River above Millville is the city of Vineland, the domestic and industrial wastes from which are discharged into a small tributary, after being passed through a sewage disposal plant.

A sanitary survey of Vineland showed that practically all streets of the town were sewered. There are 1,549 connections to the city sewers, serving 88.5 per cent of the population, or about 5,500 people. The remainder of the population, in 200 homes, use privies with water-tight receptacles, which are emptied weekly, the contents being hauled to a farm outside of town and plowed under. Strict supervision by the local board of health virtually precludes the possibility of stream pollution from these privies. All trade wastes are passed through the disposal plant and mixed with the domestic sewage.

The sewage disposal plant of Vineland is located at one edge of the town and covers an area of about six acres. The method of treatment of the sewage consists of sedimentation in a series of basins formed by embankment, filtration through underdrained sand beds, and disinfection of the filter effluent by means of hypochlorite of lime solution. The sedimentation beds are inadequate for the purpose of taking care of the quantity of sewage coming to them, and the sand filters are heavily overloaded. The entire plant is in urgent need of enlargement and rearrangement. It is at present necessary to run some of the sewage to improvised settling basins, from which it is discharged direct to the creek, without sand filtration or hypochlorite disinfection. The final effluent is discharged into the Tarkiln branch of the Maurice River.

Analyses of the effluent of the Vineland sewage disposal plant, published in the Annual Reports of the State Board of Health of New Jersey for 1909 to 1912, inclusive, show an average of 300,900 bacteria per cubic centimeter at 20°, and 26,800 bacteria at 37°, with an average count of 5,900 *B. coli* per cubic centimeter. The average total solids is 161 parts per million, and the average relative stability is 40. From these figures it is apparent that considerable improvement in the quality of the effluent is desirable.

In addition to the municipal disposal plant there are two other sewage disposal plants serving institutions at Vineland. The Training School for Feeble-Minded Children disposes of all wastes by sedimentation and broad irrigation on farm land. There is no effluent discharged from this area. The Home for Feeble-Minded Women has a somewhat similar process, and it is believed that little actual pollution of the water course results from this source.

The large lake above Millville and below Vineland probably has a beneficial effect on the river water, due to the storage period afforded, with consequent sedimentation. Analyses of water taken from the

outlet of this reservoir show in many cases evidence of slight pollution, although these analyses have not been extended over a long enough period to warrant definite conclusions as to the safety of the stream at this point.

II. RIVER BELOW MILLVILLE.[1]

Sources of pollution.—The river is tidal the entire distance from Millville to its mouth. From Millville the stream flows southeast, then southwest, to Maurice River Cove, a distance of 24 miles. For the first four miles below Millville, the river flows between wooded bluffs of sand, gravel, and clay, interspersed with rolling farm lands. Two miles above Mauricetown, salt marshes appear on the right bank, the upland receding more and more. On the left bank, the fast land continues to within 2 miles of the mouth, where salt marshes appear. Considerable areas of these lowlands have been banked and are under cultivation, and this work is being extended at the present time.

The channel from French's Bar to Millville has been dredged to a minimum depth of 7 feet. Below French's Bar the controlling depth is over 10 feet at mean low water, while in places it reaches 40 to 50 feet.

At Millville the low-water width is about 100 feet. The river gradually widens until, in the lower reaches, it varies in width from 500 to 1,000 feet.

There are four tributaries of considerable size to the main stream between Millville and Mauricetown. White Marsh Run and Buckshutem Creek drain the area to the west, while Menantico and Manumuskin Creeks drain the wilderness to the east.

The drainage area of the Maurice River between Millville and the mouth of the stream is 179 square miles; it is very sparsely populated, and has no source of direct pollution except Millville. The several small settlements along the banks have no sewers and so discharge no wastes directly into the stream. Some of the land is under cultivation, and this may contribute a small amount of pollution to the main stream. A fish-rendering plant located about 2 miles above Bivalve contributes a considerable amount of organic matter to the pollution.

The most evident and serious pollution of the river is caused by the city of Millville.[2] Millville is a rather busy industrial community employing a considerable amount of labor of a low grade. The enforcement of sanitary regulations has been neglected, and sanitary conditions are therefore not of the best.

---

[1] See Map No. 11.

[2] Population 12,451 in 1910, and an estimated population of 13,437 in 1915.

A sanitary survey of Millville indicated that probably 4,500 of the population are connected to the sanitary sewers; although lack of records makes it difficult to confirm this figure definitely. The remainder of the population depends upon cesspools and privies, many of which are in bad condition.

The sanitary sewers are poorly constructed and admit excessive amounts of ground water, a condition which, along with others, has led to the inefficient operation and practical neglect of the sewage-disposal plant at the lower end of the town.

The disposal plant consists of sedimentation tanks operated in series, an aeration well, contact beds, copper sulphate disinfection, and a tidal storage tank. At the time of the investigation the sedimentation tanks were seriously clogged and the contact beds entirely so. It was stated that copper sulphate was being added, but this has probably little effect on the bacterial content. As a result the river was seriously polluted at this point by the discharge of poorly treated sewage from a population of at least 4,500 people. Raw sewage also is discharged directly into the river from a section of the city too low to drain by gravity to the disposal plant. It is believed the industrial wastes are not important from a bacterial standpoint and add little pollution of this nature.

The various settlements along the river between Millville and Bivalve also must be considered as possible sources contributing pollution to the stream. While none of the sewers in these towns empty directly into the river, they nevertheless drain indirectly to the watercourse. Sanitary regulations are not enforced in these places, and in some cases privies are located close to the banks. In times of heavy washing rains the danger from pollution from these villages may become important. Attention must be paid to this source of pollution to insure a satisfactory quality of the water in Maurice River.

The only other apparent sources of pollution affecting the oyster floats are the towns of Bivalve and Maurice River themselves, and the oyster boats plying the river at these points. The local boards of health have realized the dangers of pollution from these sources and have taken active steps to reduce them to a minimum. A complete system of scavenger service for the boats has been organized, and all excreta on the boats are deposited in cans, which are removed daily by a scavenger, and taken to farm land, all cans being cleaned and disinfected. Several privies still exist back from the shore line, but, it is believed, out of range of probable chances of directly polluting the river. Additional toilet facilities for the accommodation of the laborers employed in handling oysters will no doubt prove a benefit to local sanitary conditions near the oyster floats. Constant atten-

tion to the scavenger system will be necessary to produce effective results from this service at all times.

Tides and currents.—The tides play an important part in the flow of Maurice River from Millville to its mouth, and it is therefore necessary to consider them in connection with the transmission of polluting substances from Millville to the oyster floats at Bivalve. The tides of Maurice River are discussed in the report to Congress of E. A. Gieseler, Assistant Engineer United States Army, in reporting on improvements for that stream, and from this report the following information has been obtained.

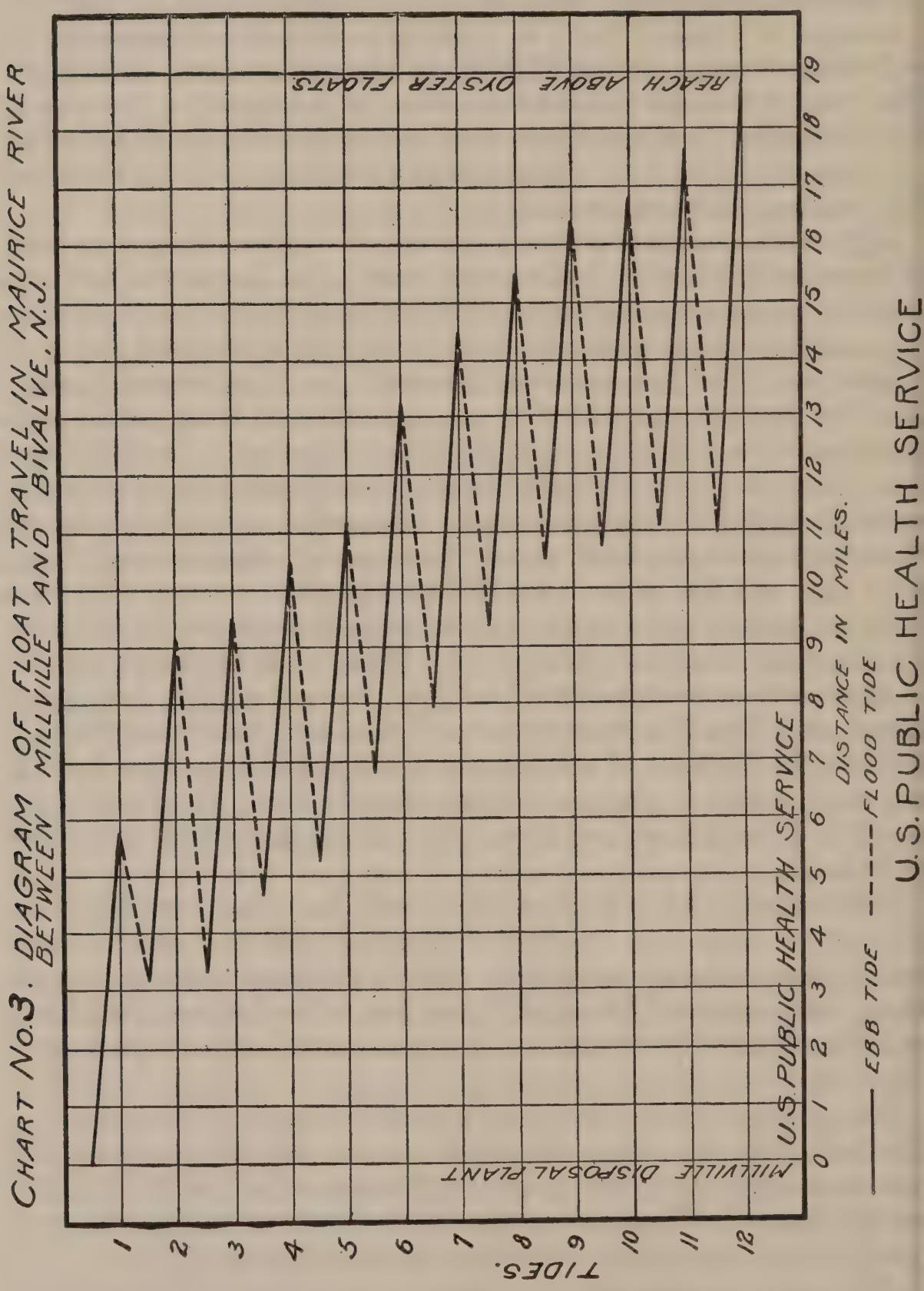
High and low water levels both traverse the distance from the mouth of the river to Millville in about the same time, about two and one-half hours; but while the motion of high-water level is accelerated as it passes upstream, low-water level is retarded in about the same proportion. The distance from the mouth to Mauricetown is traversed by the high-water level in one and one-half hours, while from Mauricetown to Millville only one hour is consumed. The low-water level, on the other hand, traverses the same distance in one hour and one and one-half hours, respectively. Changes of current take place at the mouth about one hour, and at Mauricetown about one-half hour, after high and low water. At Millville the flood current changes a little before high-water stand, while ebb current changes about three-fourths hour after low-water stand. Thus, while at the mouth and at Mauricetown the duration of the flood current and ebb current are respectively equal to the duration of rise and duration of fall, at Millville the duration of ebb current is one hour longer than the fall, and that of flood is one hour shorter than the rise. The average rise and fall of the tide is about 6 feet at the mouth and a little over 5 feet at Millville.

The mean tidal prism of the river has been computed at 500,000,000 cubic feet, of which 20,000,000 cubic feet may be fresh water received during flood tide. About the same amount of fresh water being received during ebb tide, the entire discharge in 6 hours and 20 minutes of the ebb at the mouth amounts to about 520,000,000 cubic feet.

The greatest mean velocity of the ebb current at the mouth is reached about 4.3 hours after high water. The discharge at this time, through a cross section of 11,400 square feet, is 29,000 cubic feet per second. The same calculation for Mauricetown gives a much smaller figure, due to the flooded meadows below the village.

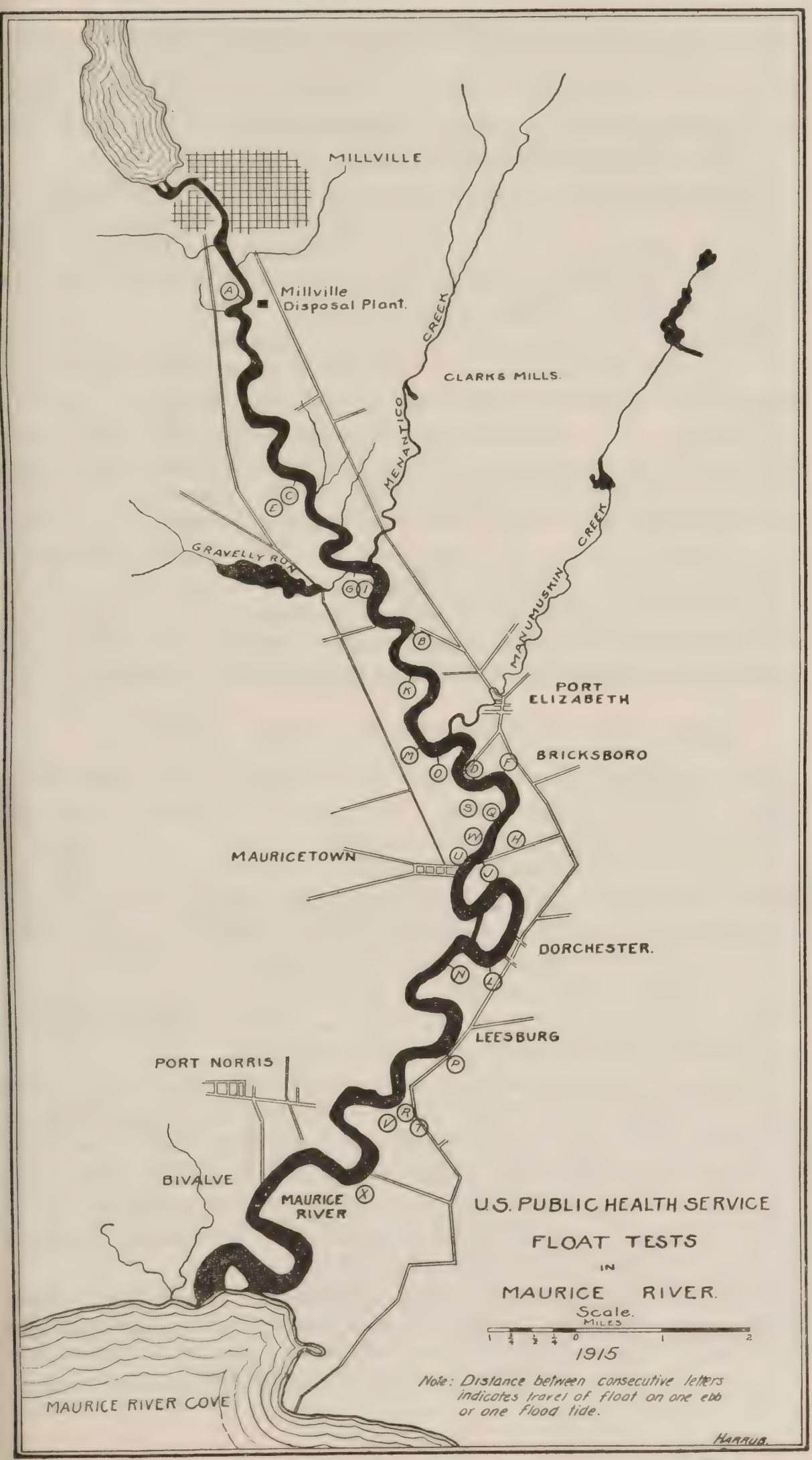
Float tests.—In order to determine the time required for sewage to flow from Millville to the oyster floats at Bivalve, a series of float tests was undertaken and carried out jointly by the State department of health, and the United States Public Health Service. It is realized that these experiments gave only approximate results, and

not enough of them were made to determine exactly the time required, but it is believed a reasonably fair idea of the currents can be had from them.



It was found that winds greatly influenced the speed and course of the floats, although they were submerged to a depth of 4 feet with a very small area exposed. For this reason, it was decided that more nearly accurate results could be obtained by using the floats only on

MAP NO. 11.


MILLVILLE
Millville Disposal Plant.
A
MENANTICO CREEK
CLARKS MILLS.
E
C
GRAVELLY RUN
G
I
MANUMUSKIN CREEK
B
K
PORT ELIZABETH
BRICKSBORO
M
O
D
F
S
Q
W
H
MAURICETOWN
U
J
DORCHESTER.
N
L
LEESBURG
PORT NORRIS
P
V
R
T
BIVALVE
MAURICE RIVER
X
MAURICE RIVER COVE
U.S. PUBLIC HEALTH SERVICE
FLOAT TESTS
IN
MAURICE RIVER.
Scale.
MILES
1 3/4 1/2 1/4 0 1 2
1915
Note: Distance between consecutive letters indicates travel of float on one ebb or one flood tide.
HARRUB.

comparatively calm days. The floats were always allowed to run a full tide without interruption, except to keep them in the channel and prevent them from stranding. The accompanying chart shows the time required to float from the disposal plant at Millville to the reach above the oyster beds at Bivalve.

These experiments indicated that sewage from Millville may be expected to reach the oyster beds at Bivalve in six days. Under favorable conditions, this time may be shortened. It is probably safe to say that from 5 to 10 days is required for water from Millville to reach Bivalve and Maurice River.

There is a certain amount of sedimentation taking place during this time, due to the numerous reversals of current and also due to the mixing of the fresh and salt water, with the consequent apparent precipitation of a certain amount of color in the fresh water; the velocity of the stream, however, is such that the benefit derived from sedimentation may be comparatively small. The maximum distance traversed by the floats on one ebb tide was $7\frac{1}{2}$ miles in 5.6 hours, or an average rate of 1.96 feet per second. The highest rate during this time indicated a velocity of about 2.6 feet per second. It is believed that this velocity is high enough to prevent any sedimentation of consequence and probably would have a tendency to stir up considerable finer sediment deposited during slower velocities.

RESULTS OF EXAMINATIONS OF OYSTERS AND WATER.

Three hundred samples of oysters and water were collected in Maurice River for examination. The results of determinations of free oxygen present in water of the river (Table V, p. 122) show a minimum of 63.8 per cent of saturation near the sewer outfall at Millville, with a loss, after 24 hours incubation at 20°, of 0.60 p. p. m.; while near oyster floats at Bivalve it varied from 75 to 87.9 per cent of saturation, with a maximum loss on incubation of 1.35 p. p. m.[1]

It is evident, therefore, that while there is a deficiency in free oxygen, the lower reaches of the river are not seriously overloaded as far as unsatiated organic matter is concerned.[2]

During the investigation there were examined 96 samples of oysters floated at Maurice River and Bivalve, the two shipping points on the river, for varying periods of time; of these some were taken from shipping houses and barges, some from floats, and others were duplicates of samples collected by the party on the *Bratton* in Maurice River Cove and floated in the river for comparison. The results obtained are recorded in detail in Tables V and W, pp. 122–127.

It will be noted that two samples examined October 4, gave scores of 320 each. These were from a few oysters in an unused float out

[1] See also Table W. [2] See Chart 4.

of the water and exposed to the sunshine and the length of time that they had been floated is unknown No other samples taken at any time scored over 41. Of the 96 samples—

2, or 2.10 per cent, scored 320; 5, or 5.20 per cent, scored 41; 6, or 6.25 per cent, scored 32; 8, or 8.30 per cent, scored 23; and 75, or 78.13 per cent, scored 14 or less.

During the same period 89 samples of water were collected in this floating area and examined, of which—

86 or 96.75 per cent showed *B. coli* present in 10 c. c. quantities; 3, or 3.25 per cent, showed *B. coli* absent in 10 c. c.; 21, or 23.59 per cent, showed *B. coli* present in 10 c. c. but not in 1 c. c.; 4, or 4.49 per cent, showed *B. coli* absent in 1 c. c.; 47, or 51.68 per cent, showed *B. coli* present in 1 c. c. but not in 0.1 c. c.; and 15, or 16.85 per cent, showed *B. coli* present in 0.1 c. c.

Or, discarding the four samples, which were negative in 1. c. c. but which were not planted in 10 c. c. quantities—

3, or 3.52 per cent, showed *B. coli* absent in 10 c. c. quantities; 82, or 96.47 per cent, showed *B. coli* present in 10 c. c. quantities; 61, or 71.76 per cent, showed *B. coli* present in 1 c. c. quantities; and 15, or 17.64 per cent, showed *B. coli* present in 0.1 c. c. quantities.

The results obtained from samples taken along the course of the river below the disposal plant at Millville show a gradual decrease in the mean *B. coli* content of the water from 46.5 *B. coli* per c. c. to a mean average of 0.7 *B. coli* per c. c. in the floating area, as is shown in the following table:

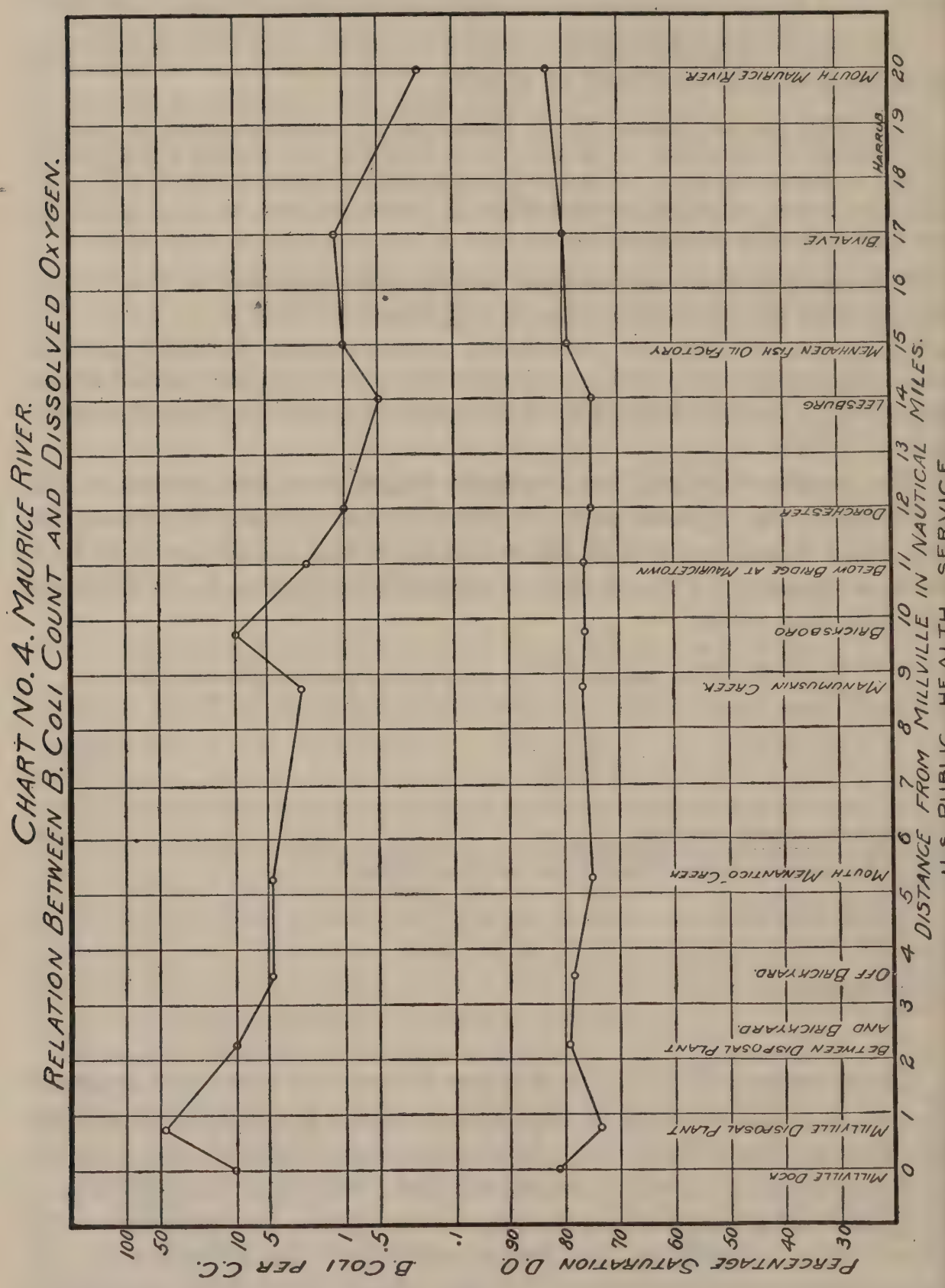
TABLE 8.—*Mean number of B. coli per c. c. of water in Maurice River.*

Station.	Mean number of B. coli.
Millville above sewage disposal plant	10.0
Off outfall of Millville sewage disposal plant	46.5
Midway between Millville sewage disposal plant outfall and brickyard	10.0
Brickyard	3.2
Mouth Manantico Creek	3.2
Mouth Manumuskin Creek	2.7
Mauricetown	2.1
Dorchester	1.0
Leesburg	.3
Fish-rendering factory	.5
Floating area	.7

The samples taken in the various tributaries show the average *B. coli*, in those sections of the streams above the tidal influx from the Maurice River itself, to be lower than the average *B. coli* content of the main river; hence it seems evident that the main pollution is from Millville rather than from any other source. It is probable that after heavy rainfall on the lower watershed the pollution in the river is somewhat augmented by the run-off from fields and other rural sources; but, because of the sparsely settled condition, the sandy soil, and flat terrain of the district, it is not probable that much additional pollution of any kind thus reaches the river.

TYPHOID FEVER ON THE MAURICE RIVER WATERSHED.

A study of the prevalence of typhoid fever on the watershed was made by Assistant Surgeon Waller, based upon statistics secured by the New Jersey Department of Health, inspection of local records,



and personal interviews with physicians in the various localities, as a result of which it was ascertained that Millville, with a population of 12,451 in 1910, had an average of 12.5 cases per annum during the

period 1907 to 1915, the maximum number of cases reported having been 20 in 1913–14, and the minimum 1 in 1909–10.[1]

The greatest danger of infection of the river with typhoid organisms is during the months from August to December, the peak of the typhoid-fever curve being quite constantly in August or September. It is at the beginning of September that the oyster season opens and the floating of oysters is begun. The water in the river at this period is warm, and oysters are physiologically active and feed rapidly.

Commercial Township, Landis Township, and Maurice River Township, with Millville, comprise the whole watershed in the tidal area.

Commercial Township, with a population of 2,604 in 1910, includes the town of Bivalve, the great floating and shipping center; Port Norris, a community about 1 mile from the river near Bivalve; and Mauricetown, on the river about half way between Millville and Bivalve.

There have been only 8 cases of typhoid fever reported from this township within the last eight years, three cases having been reported in September and October 1913–14, respectively. Most of the cases have occurred during those months. Personal interviews with local physicians seemed to confirm the above figures.

Maurice River Township includes the floating and shipping center of that name, opposite Bivalve, and also the small communities, Heislerville and Leesburg. The total population in 1910 was 2,124, and the total number of cases of typhoid reported for the past eight years was 17, of which 5 occurred in June and 4 in February. From September to December there were 5 cases in the eight years.

Landis Township, with a population of 6,435 in 1910, had a total of 15 cases reported in the eight-year period, nearly all of which were between August and December. This township adjoins Millville on the south side of the river and reaches to Maurice River Township.

SUMMARY.

The principal pollution in that portion of Maurice River used for floating oysters is sewage discharged into the stream by the city of Millville. Some of the polluted water probably reaches the oyster floats at Bivalve and Maurice River in from 5 to 10 days, depending upon the rapidity of stream flow and direction and force of prevailing winds. Sedimentation between these points should not be relied upon to eliminate the danger of pollution of oysters.

The various small communities along the river are potential, if not actual, sources of pollution of the stream.

Bacteriological examination of the river water in which oysters are floated shows a considerable amount of pollution, indicated by the

[1] See Appendix II, p. 135 et seq.

constant presence of *B. coli* in amounts of water varying from 0.1 c. c. to 10 c. c., with a mean average of 0.7 *B. coli* per c. c.

Examinations of numbers of samples of oysters when taken from the beds in Maurice River Cove showed little pollution, while the examination of oysters after floating in Maurice River showed constantly some pollution acquired by immersion in the river water; however, with the exception of two samples which had been on a float for an undetermined period, none of these samples taken during any season showed scores sufficiently high to condemn them under the present standards.

A study of the prevalence of typhoid fever in that portion of the watershed adjacent to the communities engaged in floating and shipping oysters showed a very low typhoid rate.

As has been shown, the typhoid-fever incidence at Millville is higher than that in the surrounding country. A study made by the New Jersey Department of Health showed that it was a daily custom of men engaged in the business to open and eat large numbers of oysters to ascertain when they were ready for shipment, and these men also carried quantities of raw oysters to their families. Notwithstanding this there is an absence of typhoid fever among them. The writer's observations confirm this fact.

CONCLUSION AND RECOMMENDATIONS.

Taking into consideration all the factors which may directly or indirectly contribute infectious pollution to Maurice River, it is doubtful if the waters of this stream can be considered, under present conditions, a safe place in which to float oysters.

In view of the above, the method of treating the sewage at Millville should be promptly modified by increasing the efficiency of the present disposal plant and by eliminating the discharge of all raw sewage into the stream, so that the effluent will not be a source of serious pollution.

We have been informed by the New Jersey State Department of Health that a chlorine gas disinfection plant has been ordered and will be installed in the Millville disposal station in the near future. If efficiently operated this should remove the chief source of infectious pollution.

Sanitary privies or cesspools, or other suitable safeguards should be installed in the small communities below Millville. Unrelaxing vigilance should be exercised in enforcing sanitary regulations at Bivalve and Maurice River to prevent local pollution of the stream.

Under such conditions the oysters floated in this river will be safe.

COHANSEY RIVER.

SANITARY SURVEY.

The Cohansey River rises in Salem County and flows for 13 miles nearly due south to Fairton, and thence 8 miles west to Delaware Bay. The drainage area, as shown on map No. 11, page 69, comprises 109 square miles, most of which is flat sandy land, common to southern New Jersey. The river is tidal and navigable to Bridgeton, a distance of 9 miles in a direct line from the mouth and 19 miles following the course of the stream.

The drainage area above Bridgeton is about 48 square miles in extent; it is largely an agricultural region, with no settlements of any considerable size, and no towns have public sewers draining to the water course. The watershed is rather sparsely settled, and most of the pollution is drainage from cultivated farm lands and a few rural communities.

The watershed below Bridgeton, comprising an area of 61 square miles, is largely low flat ground, much of which is not cultivated and some of which is protected from flooding at high tide by artificial banks constructed along both sides of the stream. There are no tributaries of importance below Bridgeton, and no towns having public sewers contributing direct pollution to the stream.

Analyses of the raw water of Cohansey River above Bridgeton made by the State board of health show the presence of *B. coli* rather consistently. During the year 1914, out of a total of 11 samples examined, 8 indicated *B. coli* present in 1 c. c., 1 in 0.1 c. c., and 2 not present in 5 c. c. From this it is evident that, notwithstanding the rather sparsely populated watershed above Bridgeton, considerable pollution reaches the stream. This pollution is rightly considered so serious by the city of Bridgeton that a modern mechanical filtration plant has been installed for the treatment of the public water supply.

The principal source of direct pollution of the upper Cohansey River by domestic sewage is the city of Bridgeton, located on both sides of the stream, 19 miles from its mouth and about 17 miles from the oyster floats at Greenwich Pier.

Bridgeton in 1910 had a population of 14,209 and an estimated population in 1915 of 14,365. The State census of 1915 gives a population of 13,840, showing a loss since the Federal census of 1910. The town is a busy industrial community and the principal market center for a rather extensive farming area in this section of the State.

A sanitary survey of Bridgeton showed that there are recorded 420 connections to the sanitary sewers. A house to house canvass, made in 1909, showed that 598 houses were connected to the sewers, as stated in the report of Mr. Clyde Potts to the city of Bridgeton, under date of December 7, 1909. From this it is evident that not all connections are recorded, and it is therefore difficult to estimate the exact number of inhabitants contributing sewage. A fair estimate as to the number of people using the public sewers would perhaps be 4,000. It is estimated that of the remainder, 21 per cent use cesspools and 50 per cent privies, and these are scattered in all parts of the town. The privies are mostly of the surface type, and some of them overhang small tributary streams. In time of heavy rains this part of the population will contribute serious pollution to the stream, due to the rather rapid drainage of the town to the Cohansey. Frozen ground in the winter months will aggravate this condition.

The sewage from the public sewers is supposed to be treated in two disposal plants, one located on each side of the river, at the downstream edge of the town.

The method for treatment consists of sedimentation in covered tanks, the application of hypochlorite of lime solution to the settled sewage, and secondary sedimentation, followed by discharge into the creek. Owing to the topography of the city, it is necessary to pump some of the sewage from the sewer mains to the sedimentation tanks. At the time of visiting this plant, the pumps were not operating, and as a result, the low level sewage flow was being by-passed around the sedimentation tanks and discharged into the creek without any practical disinfection. At one of the disinfection plants the hypochlorite solution tank was empty and consequently no treatment was being secured.

Two separate visits were made to these plants and both times the operation was found to be deficient. The conclusion formed was that the operation was careless and inefficient; that no uniform treatment was being given the sewage of the city; and that considerable pollution was being contributed because of this neglect.

It was stated locally that various private sewers were discharging domestic sewage directly into the stream. No such sewers were located, although several apparently abandoned private sewers were found.

There is also considerable pollution of the Cohansey by the various industries located at Bridgeton, but there is little, it is believed, that would increase the colon content to any appreciable extent. A number of canning factories discharge large amounts of waste and a dyeing establishment discharges a considerable amount of dye waste, wash waters, and spent bleaching solutions.

The only settlement of any size between Bridgeton and Greenwich is the village of Fairton, about 4 miles below Bridgeton, with a population of about 400. Fairton has no public sewers, the entire population depending on privies, mostly of the surface type.

The nearest source of pollution of the oysters floated in the Cohansey is at Greenwich Pier, where the floats are located. Sanitary conditions here could be considerably improved by a more active local control. While much has been done, there still remain numbers of shacks and boats in the vicinity, which of necessity contribute pollution to the stream. While the number of oyster boats in the Cohansey is comparatively small, the danger from pollution from this source certainly exists and, in the vicinity of the oyster floats, may be at times the cause of gross pollution.

STREAM FLOW.

Little data on stream flow of the Cohansey River is available. The New Jersey State Geological Survey Report for 1894, Vol. III, page 257, estimates the rainfall of an average year as 45.88 inches, of which 19.61 inches is assumed to run-off, giving an average flow at Bridgeton of 46,650,000 gallons per day. The same figures for an ordinary dry year are 36.80 inches rainfall and 40,400,000 gallons per day flow at Bridgeton, while for the driest period the monthly rainfall is given as 0.94 inches, with 0.30 inches flowing off, corresponding to a flow at Bridgeton of 8,400,000 gallons per day.

Since the portion of the river from Bridgeton to the mouth is tidal, it also receives considerable amounts of sea water, which tends to dilute the sewage from Bridgeton. The entire channel acts somewhat as a tidal basin, a large body of water flowing back and forth with the rise and fall of the tide and moving gradually toward the mouth of the stream. Potts, in his report above mentioned, estimates that this basin holds 3,750 million gallons of water, and that 1,500 million gallons of sea water enter the lower reaches every day. Just how much sedimentation is effected in this basin has not been determined, but the same conditions of reversal of current and mingling of land and sea water occur in the Cohansey as in the Maurice River.

In order to study the currents in the stream below Bridgeton, Potts made numerous float experiments from which he determined that one ebb tide would carry a float from Bridgeton a distance of $4\frac{1}{4}$ miles down stream, and that the following flood tide would return the float to within 800 feet of the original starting point. His deduction from these tests was that the net gain of the water at each ebb tide averages 1,000 feet, and that during the winter months, when the run-off is greatest, the gain may be as much as 2,500 feet per tide. Assuming these figures to be correct, the minimum time

required for sewage from Bridgeton to reach Greenwich Pier, traveling a distance of 17 miles, would be about 13½ days, remembering that the last ebb tide would carry the sewage a distance of 4¼ miles. Various elements, such as height of tide, velocity and direction of wind, and excessive run-off for certain periods, may tend to shorten this time by a considerable amount.

BACTERIOLOGICAL STUDIES.[1]

There were examined 31 samples of water from that portion of the river in which the oyster floats are anchored. Of these—

2, or 6.45 per cent were negative for *B. coli* in 10 c. c. quantities; 7, or 22.58 per cent were positive for *B. coli* in 10 c. c. quantities, but not in 1 c. c.; 15, or 48.38 per cent were positive for *B. coli* in 1 c. c. quantities, but not in 0.1 c. c.; and 7, or 22.58 per cent were positive for *B. coli* in 0.1 c. c. quantities.

Or—

2, or 6.45 per cent were negative for *B. coli* in 10 c. c. quantities; 29, or 93.54 per cent were positive for *B. coli* in 10 c. c. quantities; 22, or 70.96 per cent were positive for B. coli in 1 c. c. quantities; and 7, or 22.58 per cent were positive for *B. coli* in 0.1 c. c. quantities.

The results from samples taken at Bridgeton and various points down the river indicated a gradual decrease in the number of *B. coli*, as shown by the following averages computed from the above data:

TABLE 9.—*Mean number of B. coli per c. c. of water at certain points in Cohansey River.*

Station.	Mean number of B. coli.
Bridgeton	63
Bridgeton, 1 mile below town	56.23
Bridgeton, 3 miles below town	10
Fairton	10
Island below Fairton	4.6
Third reach above Wetherells	4.6
Wetherells	10
Fourth reach above Laning wharf	2.1
Laning wharf	3.2
Area of floats	.75

The oyster business on the Cohansey River, where there are only three shippers is very much smaller than that on the Maurice River. The river is used for floating oysters grown on the Delaware side of Delaware Bay. These oysters are brought to Greenwich Pier, floated in the same manner as at Bivalve and Maurice River, and shipped in the shell by rail.

Of 57 samples of oysters floated at Greenwich Pier, 1 scored 410, 1 scored 320, 2 scored 41, 2 scored 32, 4 scored 23, and 47 scored 14 or less. The two high scores were encountered at different seasons of the year, one in October (temperature of water 16.6°), and one in

[1] See Tables Y and Z, pp. 131–134.

December (temperature of water 0.5°). It is believed that these oysters were polluted by excreta from vessels lying at or near the floats.

For typhoid fever studies see Appendix II, page 135.

SUMMARY.

The source of most of the pollution found in the Cohansey River is the city of Bridgeton. There is also the possibility of pollution, small in amount but dangerous in character, from such communities as Fairton.

So far as may be judged by the study of floats, currents, tides and stream flow, the time factor in purification between Bridgeton and Greenwich Pier is greater than that between Millville and Maurice River and Bivalve on the Maurice River.

While the number of vessels engaged in the industry at Greenwich Pier on the Cohansey is much smaller than the large number at Bivalve and Maurice River, nevertheless there is a constant potential danger of infectious pollution by fresh excreta from the persons on the vessels which lie quite near the floats.

CONCLUSIONS.

In view of these facts it seems fair to conclude that under present conditions the waters of the Cohansey River at Greenwich Pier are not entirely safe for the floating of oysters.

The discharge of all raw sewage into the river at Bridgeton should be stopped either by connection to the sewage disposal plants at Bridgeton or the installation of safe forms of privy disposal.

The use of by-passes at the Bridgeton disposal plants should be discontinued. These plants should have such constant competent supervision as will insure a safe effluent at least throughout the oyster floating season.

Sources of pollution along the river should be eliminated. At Greenwich Pier there should be instituted a system which will remove the danger of pollution from vessels and oyster houses in the vicinity of the floats.

INFECTIOUS DISEASES AND POLLUTION OF COASTAL WATERS.

While the bacteriological examination of the waters and shellfish, together with a sanitary survey of the contributing watershed, furnishes fairly accurate knowledge of the total amount of pollution from human sources, it is quite obvious that in order to obtain data as to the actual danger from the presence of the causative organisms of such diseases, it is necessary to know both the amount of such diseases on the watershed and their relation to the use of the waters in question for bathing purposes and as sources of shellfish. In other words, it is essential to inquire into methods of transmission in order to ascertain whether such use of the coastal waters has given rise to outbreaks of typhoid fever or other intestinal infection.

The typhoid fever statistics of the communities on the various watersheds have been secured from the State Department of Health by Passed Asst. Surg. Frost, under whose direction a sanitary survey of New Jersey was being made, and from other sources. They will be found in Appendix 11, page —.

In addition, Passed Asst. Surg. Draper was specially detailed to visit the communities along the coast adjacent to the water areas under investigation for the purpose of securing any possible additional information as to whether the use of such waters for sewage disposal, bathing, or as sources of sea food had any influence in the transmission of disease.

Health authorities and practicing physicians in the cities and villages on the New Jersey coast were consulted by Dr. Draper in regard to this question and the records of typhoid fever and other intestinal diseases for 10 years past were carefully examined.

With the exception of certain cases of typhoid fever which occurred at Atlantic City in 1902 and certain other cases at Ocean City in 1910, which have been previously fully reported by State and local health authorities, no relationship between the use of the waters for the purposes above mentioned and the occurrence of typhoid fever and other intestinal diseases was found.

Nevertheless, the historic outbreaks at Wesleyan University, Conn., Lawrence and Goshen, N. Y., those at Atlantic City and Ocean City, as well as those of Portsmouth, Plymouth, and Southampton, England, Cette and other places in Europe, very clearly point out the danger from oysters taken in grossly polluted waters.

The outbreak at Atlantic City in 1902, to which allusion has been made, was thoroughly studied by Dr. Edward Guion and Herbert

F. Snow, who showed that the epidemic was due to the eating of oysters floated and clams taken at the mouth of the Penrose Canal.

This canal was shown to have been discharging an unusual amount of sewage, owing to a break in a large sewer, laid in the canal, which carried a considerable amount of the city sewage out into the "Thoroughfare."

Snow found "1,000,000 organisms per c. c. at 37°, of which nine-tenths were intestinal," in the water immediately over the outlet, and "1,150 37° organisms of which 520 per c. c. were of intestinal origin," at a distance of 1,000 feet from the sewer outlet.

Guion wisely concludes "there is a zone of pollution established by the mere fact of the existence of a populated city upon the banks of a stream, or tidal estuary which makes the laying down of oysters and clams in these waters a pernicious custom if persisted in, because it renders these articles of food dangerous at times, and always suspicious."

69263°—17——6

GENERAL SUMMARY AND CONCLUSIONS.

Shellfish growing and shipping constitute one of the most important industries in the State of New Jersey, the annual oyster crop being valued at from $2,000,000 to $4,000,000.[1]

As a result of the laboratory examination and sanitary surveys made by the service, it has been determined that the waters in which these shellfish are grown are, with the exception of the small areas described, free from pollution. However, almost all of the oysters grown in these waters are removed to small creeks or rivers, where the salinity of the water is less, for the purpose of "floating" or "freshening" before shipment.

The sanitary condition of such oysters depends upon the condition of these creeks rather than that of the beds on which they are grown, and some of these "drinking" places have been found to be unsatisfactory.

Throughout the State the New Jersey Department of Health has been found to have been active in attempting to remedy dangerous conditions wherever they exist, and it is believed that this organization as at present constituted will do even more efficient work in the future.

In addition to the great value of the coastal waters of New Jersey in connection with the shellfish industry, these waters are of far greater value because of the number of summer resorts along the whole shore from Sandy Hook to Cape May.

The protection of these waters from pollution and nuisance is therefore of the utmost importance to the State, and because shellfish are shipped from the State throughout the country, and the resorts are visited annually by hundreds of thousands of citizens of other States, the sanitary conditions of the resorts and of the coastal waters is a matter of national moment.

People who go to such resorts are gradually being educated by the various public health agencies as to the possible danger of contracting diseases in insanitary surroundings, and are beginning to consider the healthfulness of a resort as an important factor in determining where they shall spend their vacation. As a result the citizens of the resorts are beginning to realize the monetary value of good sanitary measures, and there seems to be a general appreciation of the necessity for maintaining good sanitary conditions in the communities along the coast.

This is manifested by the increased activity of local as well as State authorities in reporting and investigating the origin of cases of

[1] Report N. J. Dept. of Health, 1910.

typhoid fever as well as by the number of sewage-disposal plants and improved water supplies. In some instances, however, while nuisance along the beaches has been abated, and improved conditions in the communities have thus been brought about, no provision has been made for the proper disinfection of sewage effluents, which in themselves constitute a danger.

One source of considerable danger exists nearly everywhere along the inland waterways in the vicinity of communities or cottages with sewerage systems. Bulstrode and others have called attention to this danger in England. It seems to be a common custom for cottagers, boarders, and "trippers" to dig clams, for pleasure or profit, without reference to the proximity of sewer outfalls. Indeed, such places often seem on account of their convenient location to be favorite localities with such people. This problem would appear to be one for local sanitary police regulation, although it is of general interest because of the fact that these people come from all sections of the country. The use of large warning posters such as are displayed near Atlantic City is to be commended.

The shellfish areas of Delaware consist of the beds in Delaware Bay, and, while the shellfish-growing industry is of considerable importance, nearly all of the shipping goes through the New Jersey towns of Maurice River, Bivalve, and Cohansey River stations.

APPENDIX I.

DETAILED RESULTS OF EXAMINATIONS OF SAMPLES OF OYSTERS AND WATER AND DISSOLVED OXYGEN DETERMINATIONS.

TABLE A.—*Raritan River.*

No.	Location of sampling station.	Date.	Hour	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water.	
											Number colonies per c. c., agar 37° 48 hours.	B. coli.
		1915.			*Ft.*				° *C.*			*C. c.*
1	New Brunswick, 500 feet below highway bridge	Sept. 20	8.30 a. m.	Ebb	12		Fair	Heavy				[1] +0.01
2	New Brunswick, 1 mile below highway bridge	20	10.00	do	12		do	Slight				[1] + .01
3	2 miles below New Brunswick	20	10.20	do	12		do	do				[1] + .01
4	3 miles below No. 1	20	10.30	do	12		do	do				+ .1
5	½ mile above Sayreville	20	10.40	do	18		do	do				[1] + .01
6	¼ mile below brickyard at Sayreville	20	10.50	do	13		do	do				+ .1
7	1 mile below brickyard at Sayreville	20	11.00	do	25		do	do				+ .1
8	1½ miles below brickyard at Sayreville	20	11.05	do	13		do	do				+ .1
9	2½ miles below brickyard at Sayreville	20	11.15	do	13		do	do				+1
10	1 mile above railroad bridge at Perth Amboy	20	11.25	do	11		do	do				[1] + .01
11	Under highway bridge at Perth Amboy	20	11.30	do	30		do	do				+ .1
12	Under railroad bridge at Perth Amboy	20	11.35	do	19		do	do				+ .1
13	Perth Amboy, 1 mile below railroad bridge	20	11.40	do	22		do	do				+1
14	1,000 yards above Great Beds Light at junction with Arthur Kill.	20	11.45	do	24		do	do				+1
15	1,000 yards east of Great Beds Light	20	12.00 m.	do	23		do	do				[1] + .1
16	2 miles below New Brunswick	Nov. 15	10.00 a. m.	Flood	12	NW	Cloudy	0	8.9	1.0010	38,000	[1] + .1
17	Brickworks above Sayreville	15	10.30	do	20	NW	do	0	8.3	1.0010	75,000	[1] + .1
18	Brickworks at Sayreville	15	11.00	do	16	NW	do	10	8.6	1.0040	12,500	+ .1
19	Red Light No. 2	15	11.30	do	15	NW	do	25	8.9	1.0150	435	+1
20	Sandy Point	15	12.00 m.	do	39	NW	do	25	9.4	1.0190	395	[1] + .1
21	Do	Dec. 2	1.30 p. m.	do	36	SW	Snow	5	5.0		77	+ .1
22	Red Light No. 2	2	1.45	do	13	SW	do	25	5.0		183	+ .1
23	Brickworks at Sayreville	2	2.10	do	16	SW	do	50	3.9		570	[1] + .01
24	Brickworks above Sayreville	2	2.30	do	14	SW	do	10	3.9		900	[1] + .01
25	2 miles below New Brunswick	2	2.50	do	11	SW	do	0	2.8		2,100	[1] + .001

[1] Highest dilution planted.

TABLE B.—*Arthur Kill and Raritan Bay.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.		Dissolved oxygen.			
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.	Per cent saturation.	Parts per million.		
														At once.	24 hours at 20°.	Loss.
		1915.			*Feet.*				°*C.*			*C. c.*				
1	Above mouth Rahway River	Aug. 13	1.40 p. m.	Ebb	24	W	Fair	60	25	1.0085	[1] 3,000	[2] +0.1	33.7	2.55	1.95	0.60
2	Below mouth Rahway River	13	1.45	do	24	W	do	60	25.6	1.0085	[1] 1,770	[2] + .1	41.6	3.12	2.15	.97
3	Mouth of Fresh Kills	13	2.05	do	24	W	do	60	25	1.0085	[1] 1,450	[2] + .1	32.8	2.48	1.92	.56
4	Opposite P. & R. R. R. docks	13	2.15	do	24	W	do	50	25	1.0095	[1] 1,000	[2] + .1	41.0	3.10	2.73	.37
5	Red buoy above Tottenville, S. I	13	2.40	do	24	W	do	80	25	1.0110	[1] 350	[2] + .1	54.9	4.15	3.70	.45
6	Opposite Perth Amboy Yacht Club	13	2.50	do	23	W	do	30	25	1.0110	[1] 330	[2] + .1	72.1	5.45	4.15	.30
7	Junction Arthur Kill and Raritan River channels.	13	3.05	do	24	W	do	40	25	1.0115	[1] 320	[2] + .1	52.9	4.00	4.80	+.80
8	Channel, Princess Bay	13	3.30	do	25	W	do	5	25.3	1.0150	[1] 80	+1.0	78.0	5.90	5.37	.53
9	Nun Buoy entrance to Cut-off Channel	13	3.43	do	24	W	do	5	25.6	1.0135	[1] 130	[2] + .1	74.8	5.55	5.33	.22
10	Nun buoy No. 2, off Great Kills	13	4.00	Flood	24	W	do	25	26.1	1.0140	[1] 270	[2] + .1	89.6	6.65	6.65	.00
11	Junction Kill Van Kull and Newark Bay.	14	11.20 a. m.	Ebb	27	SW	do	10	25.6	1.0100	[1] 1,830	[2] + .1	48.6	3.60	3.30	.30
12	Opposite Milliken Iron Works, Elizabethport.	14	11.35	do	24	SW	do	40	25	1.0090	[1] 2,300	[2] + .1	37.4	2.80	2.80	.00
13	Mouth of Elizabeth River	14	11.55	do	18	SW	do	60	25	1.0085	[1] 6,700	[2] + .1	29.0	2.20	2.30	+.10
14	Opposite Graselli	14	12.30 p. m.	do	20	SW	do	60	25	1.0085	[1] 620	[2] + .1	35.7	2.70	2.50	.20
15	Above mouth Rahway River	14	12.45	do	24	SW	do	60	25.6	1.0090	[1] 590	[2] + .1	37.7	2.80	2.80	.00
16	Below mouth Rahway River	14	12.50	do	24	SW	do	60	25	1.0090	[1] 320	[2] + .1	38.7	2.95	2.40	.55
17	Mouth of Fresh Kills	14	1.00	do	24	SW	do	60	25	1.0095	[1] 460	+1.0	42.3	3.20	2.27	.93
18	Opposite P. & R. R. R. docks	14	1.20	do	24	SW	do	60	25	1.0095	[1] 540	[2] + .1	56.9	4.23	3.60	.63
19	Red buoy above Tottenville	14	1.40	do	24	SW	do	60	25	1.0115	[1] 40	+1.0	62.8	4.75	4.80	+.05
20	Opposite Perth Amboy Yacht Club	14	1.50	do	23	SW	do	60	25	1.0125	[1] 60	+1.0	70.1	5.30	5.30	.00
21	Junction Arthur Kill and Raritan River channels.	14	2.05	do	24	SW	do	60	25	1.0130	[1] 60	+1.0	70.0	5.25	5.15	.10
22	Nun Buoy entrance to Cut-off Channel	14	2.50	do	24	SW	do	30	25	1.0095	[1] 70	+1.0	88.7	6.70	4.95	1.75
23	Nun buoy No. 2, off Great Kills	14	3.00	do	24	SW	do	15	24.4	1.0150	[1] 80	+1.0	87.5	6.75	4.90	1.85
24	Opposite mouth joint trunk sewer	16	4.15	do	10	SW	do	25	26.1	1.0090	[1] 15,800	[2] + .001	39.1	2.90	2.15	.75
25	Above mouth Rahway River	16	3.50	do	24	SW	do	20	25.6	1.0090	[1] 1,800	+ .01	35.7	2.65	2.10	.55
26	Below mouth Rahway River	16	3.45	do	24	SW	do	20	26.1	1.0100	[1] 1,470	[2] + .01	33.1	2.45	1.90	.55
27	Mouth of Fresh Kills	16	3.30	do	24	SW	do	10	26.1	1.0110	[1] 930	+1.0	38.4	2.85	2.25	.60
28	Opposite P. & R. R. R. docks	16	3.15	do	24	SW	do	10	25.6	1.0105	[1] 680	+ .1	47.8	3.55	3.15	.40
29	Red buoy above Tottenville	16	2.40	do	24	SW	do	5	24.7	1.0130	[1] 280	+ .1	61.5	4.65	4.30	35
30	Buoy off Tottenville	16	2.30	do	24	SW	do	5	25	1.0145	[1] 160	+1.0	61.5	4.65	4.15	.50

[1] From bottom.

[2] Highest dilution planted.

TABLE B.—*Arthur Kill and Raritan Bay*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.		Dissolved oxygen.			
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.	Per cent saturation.	Parts per million.		
														At once.	24 hours at 20°.	Loss.
		1915.			*Feet.*				°*C.*			*C. c.*				
31	Off Great Beds Light	16	2.00	Ebb..	24	SW...	Fair.....	5	26.6	1.0120	[1] 98	[2] + .1	61.8	4.50	3.85	0.65
32	Junction Kill Van Kull and Newark Bay.	17	10.10 a. m.	Flood.	15	NW...	...do.....	5	24	1.0120	[1] 4,500	+ .01	45.5	3.50	2.90	.60
33	Junction Kill Van Kull and Newark Bay, west side.	17	10.20	...do...	15	NW...	...do.....	5	24.4	1.0070	[1] 3,800	[2] + .001	42.8	3.30	2.40	.90
34	Mouth of Elizabeth River	17	10.30	...do...	18	NW...	...do.....	5	24.4	1.0090	[1] 3,500	+ .01	39.5	3.05	1.75	1.30
35	Opposite mouth joint trunk sewer	17	10.40	...do...	10	NW...	...do.....	5	24.4	1.0090	[1] 5,600	[2] + .001	40.2	3.10	2.20	.90
36	Opposite Graselli	17	10.50	...do...	10	NW...	...do.....	5	24.4	1.0100	[1] 9,200	[2] + .001	35.0	2.70	2.00	.70
37	Above mouth Rahway River	17	11.05	...do...	20	NW...	...do.....	5	25	1.0100	[1] 2,900	[2] + .001	29.0	2.20	1.85	.35
38	Below mouth Rahway River	17	11.10	...do...	18	NW...	...do.....	5	25	1.0100	[1] 680	[2] + .01	32.4	2.45	2.20	.25
39	Mouth of Fresh Kills	17	11.20	...do...	16	NW...	...do.....	5	25	1.0100	[1] 700	[2] + .01	30.4	2.30	2.15	.15
40	Opposite P. & R. R. R. docks	17	11.40	...do...	20	NW...	...do.....	5	25	1.0100	[1] 370	[2] + .01	46.9	3.55	3.35	.20
41	Red buoy above Tottenville	17	12.05 p. m.	...do...	25	NW...	...do.....	5	24	1.0150	[1] 100	+ .1	61.7	4.75	4.50	.25
42	Opposite Perth Amboy Yacht Club	17	12.15	...do...	23	NW...	...do.....	5	24	1.0150	[1] 140	+ .1	65.5	5.05	4.70	.35
43	Junction Arthur Kill and Raritan River.	17	12.30	...do...	16	NW...	...do.....	5	24	1.0160	[1] 68	[2] + .1	63.5	4.90	4.50	.40
44	Off South Amboy	17	12.40	...do...	16	NW...	...do.....	10	24	1.0120	[1] 180	+ .1	56.4	4.35	4.10	.25
45	Princess Bay, opposite White Dental Factory.	17	1.15	...do...	25	NW...	...do.....	5	23.3	1.0160	[1] 120	+1.0	65.6	5.15	4.90	.25

[1] From bottom.

[2] Highest dilution planted.

TABLE C.—*Arthur Kill and Raritan Bay: Analysis of Table B.*

Name of station.	Distance from Junction Arthur Kill and Newark Bay.	Number of samples.	Percentage of samples showing B. coli present in each dilution.						Mean number of B. coli per c. c.	Total count on agar at 37° C.			Dissolved oxygen determinations.						Number of D. O. samples.
													Per cent saturation.			Loss on incubation.			
			C. c. 10.	C. c. 1.0.	C. c. 0.1.	C. c. 0.01.	C. c. 0.001.	C. c. 0.0001.		Average.	High.	Low.	Average.	High.	Low.	Average.	High.	Low.	
	Nautical miles.															p. p. m.	p. p. m.	p. p. m.	
Junction of Kill Van Kull and Newark Bay	0.0	2	100	100	100	50	0	.....	31.6	3,165	4,500	1,830	47.1	48.6	45.5	0.45	0.60	0.30	2
Milliken Iron Works	1.1	2	100	100	100	100	50	.....	316	3,050	3,800	2,300	40.1	42.8	37.4	.45	.90	.00	2
Mouth of Elizabeth River	1.8	2	100	100	100	50	0	.....	31.6	5,100	6,700	3,500	34.3	39.5	29.0	.70	1.30	.10	2
Outlet of joint trunk sewer	2.4	2	100	100	100	100	100	.....	1,000+	10,700	15,800	5,600	39.7	40.2	39.1	.83	.90	.75	2
Graselli	3.6	2	100	100	100	100	50	.....	316	4,910	9,200	620	35.4	35.7	35.0	.45	.70	.20	2
Above mouth of Rahway River	4.75	4	100	100	100	100	50	.....	316	2,075	3,000	590	34.0	37.7	29.0	.38	.60	.00	4
Below mouth of Rahway River	5.1	4	100	100	100	50	.....	.....	31.6	1,060	1,770	320	35.5	41.6	32.4	.58	.97	.25	4
Mouth Fresh Kills	6.25	4	100	100	50	25	.....	.....	5.6	885	1,450	460	36.0	42.3	30.4	.56	.93	.15	4
Opposite P. R. R. docks	7.7	4	100	100	100	25	.....	.....	17.8	648	1,000	370	48.2	56.9	41.0	.40	.63	.20	4
Red buoy above Tottenville	8.75	4	100	100	75	25	.....	.....	10	193	350	40	60.2	62.8	54.9	.25	.45	+.05	4
Buoy off Tottenville	10.8	1	100	100	0	.....	.....	.....	1.+	160	160	160	61.5	61.5	61.5	.50	.50	.50	1
Opposite Perth Amboy Yacht Club	11.75	5	100	100	60	20	.....	.....	6.3	177	330	60	69.2	71.2	65.5	.22	.35	.00	3
Opposite South Amboy	12.75	1	100	100	100	0	.....	.....	10.+	180	180	180	56.4	56.4	56.4	.25	.25	.25	1
Great Beds Light	13.75	1	100	100	100	.....	.....	.....	10.+	98	98	98	61.8	61.8	61.8	.65	.65	.65	1
Junction of Arthur Kill and Raritan River	14.0	3	100	100	67	.....	.....	.....	46.8	149	320	60	62.1	70.0	52.9	.10	.40	+.80	3
Princess Bay	16.75	2	100	100	0	.....	.....	.....	1 +	100	120	80	71.8	78.0	65.6	.39	.53	.25	2
Nun Buoy entrance to Cut-off channel	18.6	2	100	100	50	.....	.....	.....	3.2	100	130	70	81.8	88.7	74.8	.98	1.75	.22	2
Nun Buoy No. 2, off Great Kills	21.25	2	100	100	50	.....	.....	.....	3.2	175	270	80	88.6	89.6	87.5	.93	1.85	.00	2

TABLE D.—*New York side of Raritan Bay and Lower New York Bay.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Fect.*				°*C.*			*C. c.*		
46	Bed No. 363	June 28	11.15 a.m.	Ebb	8	SW.	Clear	Slight	21.6	1.0195	14	−10	2,900	32
47	Bed No. 870	28	11.25	do	9	SW.	do	do	22.2	1.0195	38	+ 1	2,200	41
48	Bed No. 667	28	11.30	do	9	SW.	do	do	21.6	1.0195	24	+ 1	1,010	41
49	Bed No. 165	28	11.40	do	9	SW.	do	do	21.6	1.0200	9	−10	2,000	50
50	Bed No. 427	28	11.50	do	12	SW.	do	do	21.1	1.0195	16	+10	1,080	50
51	Bed No. 365	28	11.55	do	12	SW.	do	do	21.6	1.0190	12	−10	260	14
52	Bed No. 943	28	12.00 m.	do	12	SW.	do	do	22.2	1.0190	20	−10	540	5
53	Bed No. 916	28	12.15 p.m.	do	14	SW.	do	do	21.6	1.0190	10	−10	760	50
54	Bed No. 915	28	12.25	do	14	SW.	do	do	21.6	1.0190	21	+10	860	32
55	Bed No. 918	28	12.35	do	13	SW.	do	do	21.6	1.0190	16	+10	440	5
56	Bed No. 958	28	12.45	do	15	SW.	do	do	22.2	1.0200	12	+ 1	690	5
57	Bed No. 967	28	12.50	do	14	SW.	do	do	22.2	1.0190	10	+10	740	32
58	Bed No. 981	29	10.15 a.m.	do	22	SW.	do	do	19.4	1.0195	300	+ 1	220	32
59	Bed No. 861	29	10.25	do	22	SW.	do	do	20	1.0195	68	+ 1	130	5
60	Bed No. 975	29	10.35	do	22	SW.	do	do	20	1.0195	420	+ 1	170	23
61	Bed No. 1006	29	11.05	do	22	SW.	do	do	20	1.0195	380	+ 1	70	32
62	Bed No. 785	29	11.15	do	22	SW.	do	do	20	1.0195	195	+ 1	60	4
63	Bed No. 930	29	12.20 p.m.	do	16	SW.	do	do	22.2	1.0190	26	+10	90	2
64	Bed No. 132	July 1	8.45 a.m.	Flood	14	NW.	Cloudy	do	21.6	1.0200	12	+10	200	0
65	Bed No. 194	1	8.55	do	12	NW.	do	do	21.6	1.0200	28	+10	800	14
66	Bed No. 622	1	9.00	do	14	NW.	do	do	21.6	1.0195	27	−10	800	14
67	1,000 yards W.S.W. from bath house at St. Elizabeth Mission.	1	9.15	do	16	NW.	do	do	21.6	1.0190	18	+ 1	3,000	14
68	Bed No. 549	1	9.50	do	15	NW.	do	do	22.2	1.0190	17	+10	400	4
69	Bed No. 787	1	10.00	do	14	NW.	do	do	22.2	1.0190	15	+ 1	800	14
70	Bed No. 270	1	10.10	do	18	NW.	do	do	22.2	1.0190	18	−10	100	23
71	Bed No. 831	1	10.20	do	14	NW.	do	do	21.1	1.0190	23	+10	100	5
72	Bed No. 307	1	10.50	F.last	20	NW.	do	do	21.6	1.0190	6	+10	100	3
73	Bed No. 369	1	11.00	do	18	NW.	do	do	22.2	1.0190	8	+10	500	4
74	Bed No. 997	1	12.10 p.m.	H.W.	24	NW.	Fair	do	21.1	1.0200	10	+10	200	32
75	Bed No. 999	1	12.30	E.beg.	24	NW.	do	do	20.5	1.0250	21	+ 1	1,000	32
76	Bed No. 991	1	1.00	Ebb	24	SW.	do	do	20.5	1.0200	108	[1] + .1	300	14
77	Bed No. 165	21	11.45 a.m.	Flood	14	None	Cloudy	5	22.7	1.0165	50	+ 1	400	140
78	Bed No. 958	21	11.55	do	14	do	do	5	23.3	1.0165	21	+ 1	1,200	32
79	Bed No. 915	21	12.05 p.m.	do	14	do	do	5	23.3	1.0165	62	+ 1	400	230
80	Bed No. 930	21	12.15	do	18	do	do	5	23.3	1.0165	160	+ 1	1,200	32

81	Bed No. 861		21	12.25	...do...	18	...do...	...do....	5	23.3	1.0165	92	+ 1	600	32
82	Bed No. 981		21	12.40	...do...	18	...do...	...do....	5	23.3	1.0165	380	[1] + .1	300	230
83	Bed No. 975		21	12.45	...do...	18	...do...	...do....	5	22.7	1.0165	480	[1] + .1	400	41
84	Bed No. 1006		21	12.50	...do...	22	...do...	...do....	5	22.7	1.0165	120	[1] + .1	400	140
85	Bed No. 785		21	1.00	...do...	18	...do...	...do....	5	22.7	1.0165	155	[1] + .1	700	50
86	Bed No. 132		26	10.20 a.m.	Ebb...	14	SE....	Fair.....	5	22.7	1.0155	9	+10	600	3
87	Bed No. 234		26	11.15	...do...	14	SE....	...do....	5	23.3	1.0150	7	+10	300	2
88	Bed near No. 831		26	11.25	...do...	16	SE....	...do....	5	23.3	1.0145	18	+ 1	200	0
89	Bed No. 643		26	11.30	...do...	11	SE....	...do....	5	22.7	1.0150	16	+ 1	400	2
90	Bed No. 932		26	11.35	...do...	16	SE....	...do....	5	23.3	1.0145	8	+ 1	400	1
91	Bed No. 215		26	11.50	...do...	12	SE....	...do....	5	23.3	1.0150	12	+ 1	400	2
92	Bed No. 233		26	12.00 p.m.	...do...	11	SE....	...do....	5	23.3	1.0150	10	+10	200	3
93	Bed No. 130		26	12.10	...do...	12	SE....	...do....	5	23.3	1.0150	14	+ 1	300	2
94	Bed No. 307		26	12.25	...do...	18	SE....	...do....	5	23.9	1.0160	20	+ 1	200	1
95	Bed No. 148		27	11.15 a.m.	...do...	15	SE....	...do....	0	23.3	1.0165	9	+10	100	3
96	Bed No. 254		27	11.25	...do...	15	SE....	...do....	0	23.9	1.0165	7	+10	700	2
97	Bed No. 997		27	11.50	...do...	24	SE....	...do....	0	23.9	1.0165	10	+ 1	600	32
98	Bed No. 999		27	12.20 p.m.	...do...	24	SE....	...do....	0	23.9	1.0170	14	−10	400	230
99	Bed No. 991		27	12.30	...do...	24	SE....	...do....	0	24.5	1.0170	8	+10	500	41
100	Bed No. 918		27	1.10	...do...	12	SE....	...do....	0	24.5	1.0165	8	+10	300	1
101	Bed No. 427		27	1.20	...do...	12	SE....	...do....	0	23.9	1.0165	16	+10	200	3
102	Bed No. 369		27	1.25	...do...	15	SE....	...do....	0	24.5	1.0160	20	+ 1	400	0
103	Bed No. 997	Aug. 5		10.55 a.m.	...do...	22	ESE...	...do.[1]...	5	22.7	1.0155	700	+ .1	60,000	14
104	Bed No. 999	5		11.10	...do...	22	ESE...	...do.[1]...	5	22.2	1.0135	[2] 490	[3] + .1	55,000	14
105	Bed No. 991	5		11.25	...do...	22	ESE...	...do.[1]...	5	22.7	1.0135	{ 1,620 (2)	[3] + .1 [3] + .1 }	41,000	32
106	Bed No. 975	5		11.35	...do...	22	ESE...	...do.[1]...	100	22.7	1.0120	35	+ 1	31,000	4
107	About ½ mile offshore near Elm Tree Beacon.	7		11.00	...do...	22	SW...	...do.[1]...	5	21.6	1.0150	280	[3] + .1	1,000	41
108	Bearings: Old Orchard Light, 184° 33′ 45″; Triangle, Great Kills, 258° 09′ 45″.	7		11.07	...do...	20	SW...	...do.[1]...	5	21.6	1.0150	530	[3] + .1	200	41
109	Old Orchard Light, 209° 52′ 30″; Great Kills Beacon, 263° 13′ 30″.	7		11.50	...do...	20	SW...	...do.[1]...	100	21.6	1.0150	780	[3] + .1	1,100	230
110	Great Kills Beacon, 268° 56′ 15″; Triangle, Great Kills, 300° 35′ 15″.	7		11.55	...do...	24	SW...	...do.[1]...	100	22.2	1.0135	410	[3] + .1	5,100	50
111	100 yards east of buoy No. 2 of Great Kills.	7		12.00 m.	...do...	18	SW...	...do.[1]...	100	23.3	1.0080	620	[3] + .1	1,000	14
112	White Dental Works, 263° 18′ 45″; Great Kills Beacon, 290° 47′ 15″.	7		12.15	...do...	18	SW...	...do.[1]...	100	23.9	1.0080	430	[3] + .1	.....	.....
113	Branch building, St. Elizabeth Mission, 311° 07′ 30″; Princess Bay Light, 348° 42′ 30″	10		10.05 a.m.	...do...	12	N.....	...do....	15	22.7	1.0125	166	[3] + .1	400	2
114	St. Elizabeth Mission, 274° 33′ 45″; Princess Bay Light, 306° 19′ 45″.	10		10.15	...do...	15	NW...	...do....	15	23.3	1.0135	137	+ 1	700	3

[1] Following stormy weather.

[2] From bottom.

[3] Highest dilution planted.

TABLE D.—*New York side of Raritan Bay and Lower New York Bay*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
115	Princess Bay Light, 339° 15′ 0″; White Dental Works, 15° 54′ 30″.	Aug. 10	10.45 a.m.	Ebb...	15	NW...	Fair....	15.....	23.3	1.0140	192	[1] + .1	500	5
116	Princess Bay Light, 313° 56′ 15″; White Dental Works, 357° 01′ 15″.	10	10.50	...do...	14	NW...	...do....	15.....	23.3	1.0130	126	+ 1	200	5
117	White Dental Works, 347° 41′ 15″; Schwab Sanitorium, 37° 27′ 45″.	10	11.00	...do...	14	NW...	...do....	15.....	23.3	1.0140	103	+ 1	300	3
118	Schwab Sanitorium, 356° 07′ 30″; Observation Tower, 56° 00′ 30″.	10	11.15	...do...	15	NW...	...do....	15.....	22.7	1.0150	220	[1] + .1	200	32
119	West Bank Light, 77° 41′ 15″; Old Orchard Light, 110° 37′ 00″.	10	11.30	...do...	15	NW...	...do....	10.....	22.7	1.0150	222	+ 1	400	2
120	Keansburg standpipe, 178° 56′ 15″; Keyport standpipe, 208° 26′ 15″.	10	11.50	...do...	15	NW...	...do....	10.....	22.7	1.0150	160	[1] + .1	500	23
121	St. Elizabeth Mission, 266° 07′ 30″; Schwab Sanitorium, 314° 07′ 30″.	10	12.00 m.	...do...	9	NW...	...do....	10.....	23.3	1.0145	157	+ 1	300	3
122	Near Old Orchard Light.....	Nov. 22	1.00 p.m.	E. last.	25	W....	Cloudy..	20.....	7.2	1.0220	15	+10	425	4
123	Bed No. 891.....	22	1.15	...do...	25	W....	...do....	20.....	6.6	1.0210	24	+ 1	345	1
124	Bed No. 977.....	22	1.25	...do...	20	NNW.	...do....	20.....	6.6	1.0210	22	+10	170	1
125	Bed No. 986.....	22	1.40	...do...	20	NNW.	...do....	20.....	7.6	1.0215	22	+ 1	540	3
126	Bed No. 1015 (north end).....	22	2.12	...do...	22	NNW.	...do....	20.....	7.2	1.0210	34	+10	415	4
127	Bed No. 1015 (south end).....	22	2.22	L. W..	20	NNW.	...do....	20.....	7.2	1.0210	32	+ 1	300	2
128	Bed No. 999.....	22	2.45	F. beg.	20	NNW.	Fair.....	20.....	7.2	1.0210	22	+10	150	3
129	Bed No. 989.....	22	3.20	Flood.	22	NNW.	...do....	20.....	7.7	1.0210	21	+ 1	.....	.....
130	Ellsworth bed, inside mouth Great Kills	23	11.00 a.m.	Ebb..	6	SW...	Cloudy..	0.....	6.1	1.0220	12	+10	325	4
131	Bed No. 919.....	23	11.20	...do...	12	SW...	...do....	5.....	6.1	1.0220	15	+10	320	3
132	Bed No. 899.....	23	11.30	...do...	12	SW...	...do....	5.....	6.1	1.0210	.....	.....	170	3
133	Bed No. 256.....	23	12.00 m.	...do...	10	SW...	...do....	0.....	6.1	1.0210	20	+10	170	1
134	Bed No. 256 (near west end).....	23	12.15 p.m.	...do...	10	SW...	...do....	0.....	6.1	1.0210	25	+10	210	3

[1] Highest dilution planted.

TABLE E.—*Raritan Bay and Lower New York Bay.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water samples.	
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.
		1915.			*Feet.*				°*C.*			*C. c.*
135	Arthur Kill, off Perth Amboy	July 13	10.20 a. m.	Ebb	22	WSW	Fair	Slight	22.7	1.0160	23	+ 1
136	do	13	10.50	do	22	WSW	do	do	23.3	1.0160	37	[1]+ .1
137	Junction Arthur Kill and Raritan River	13	11.15	do	24	WSW	do	do	23.3	1.0155	38	+ 1
138	Red nun buoy No. 8, east of Great Beds Light	13	12.30 p. m.	do	23	WSW	do	do	23.3	1.0160	17	[1]+ .1
139	White spar, east of buoy No. 8	13	1.00	do	23	WSW	do	do	23.3	1.0165	17	[1]+ .1
140	¼ mile north of Boundary Beacon	13	1.30	do	14	None	do	do	22.2	1.0165	19	+ 1
141	Eastern edge of oyster grounds off Conaskonk Point.	13	2.30	do	12	do	do	do	24	1.0160	7	+ 1
142	Western edge of oyster grounds off Conaskonk Point.	13	2.45	do	10	do	do	do	25	1.0160	12	+ 1
143	Between Boundary Beacon and western edge of oyster grounds off Conaskonk Point.	13	2.50	E. last	11	do	do	do	24	1.0160	11	+10
144	½ mile off Staten Island shore, oppostie Princess Bay Light.	13	3.05	do	11	SE	do	do	24	1.0160	12	+ 1
145	1,000 yards off Great Kills	13	3.45	L. W	10	SE	do	do	23.3	1.0160	3	+ 1
146	100 yards off Staten Island shore, at White Dental Works, near black can buoy No. 3.	13	4.00	do	30	SE	do	do	23.3	1.0160	16	+ 1
147	Wharf, White Dental Works	22	2.30	Flood	32	E	Cloudy	do	22.7	1.0170	48	[1]+ .1
148	300 yards off shore, opposite Dental Works	22	2.35	do	27	E	do	do	22.2	1.0165	27	+ 1
149	Halfway between St. Elizabeth Mission and red nun buoy No. 8.	22	2.40	do	21	E	do	do	22.7	1.0160	4	+10
150	At red nun buoy No. 8	22	2.45	do	21	E	do	do	22.7	1.0160	26	[1]+ .1
151	Halfway between nun buoy No. 8 and St. Elizabeth Mission.	22	2.50	do	21	E	do	do	22.2	1.0160	21	+ 1
152	Channel, opposite St. Elizabeth Mission	22	2.55	do	21	E	do	do	22.2	1.0170	21	+ 1
153	Channel, opposite Princess Bay Light	22	3.00	do	21	E	do	do	22.2	1.0170	13	+ 1
154	Black can buoy No. 5	22	3.05	do	26	E	do	do	22.2	1.0170	31	+10
155	Between sample Nos. 154 and 156	22	3.10	do	24	E	do	do	22.2	1.0170	16	+ 1
156	Black can buoy No. 3	22	3.15	do	24	E	do	do	22.2	1.0170	22	+10
157	¼ mile east of buoy No. 3	22	3.20	do	24	E	do	do	22.2	1.0170	23	+10
158	Black spar east of buoy No. 3	22	3.25	do	24	E	do	do	22.2	1.0170	63	[1]+ .1
159	Red spar No. 4–A	22	3.30	do	24	E	do	do	21.6	1.0170	38	[1]+ .1
160	200 yards shoreward from black and white nun buoy at end of channel.	22	3.35	do	22	E	do	do	21.6	1.0170	62	+ 1
161	¼ mile northeast of sample No. 160	22	3.40	do	21	E	do	do	21.1	1.0165	150	+ 1
162	Outer edge of oyster grounds, 1½ miles off Great Kills.	22	3.45	do	18	E	do	do	21.1	1.0165	78	[1]+ .1
163	¼ mile northeast of No. 162	22	3.50	do	18	E	do	do	20.5	1.0165	280	+ 1

[1] Highest dilution planted.

[2] Following stormy weather.

TABLE E.—*Raritan Bay and Lower New York Bay*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water samples.	
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.
		1915.			*Feet.*				°*C.*			*C. c.*
164	Red spar and can off Great Kills	22	4.00 p.m.	Flood	19	E	Cloudy	Slight	20.5	1.0170	310	[1]+ .1
165	½ mile northeast of No. 164	22	4.05	do	19	E	do	do	20.5	1.0170	300	[1]+ .1
166	½ mile northeast of No. 165	22	4.10	do	19	E	do	do	20.5	1.0170	4	[1]+ .1
167	100 yards north of Old Orchard Light	Aug. 5	11.35	E. last	19	ESE	Fair [2]	100	22.7	1.0120	37	+ 1
168	100 yards south of Old Orchard Light	5	11.00	Ebb	20	ESE	do	5	22.7	1.0150	1,200	[1]+ .1
169	do	5	11.20	do	20	ESE	do	100	22.7	1.0120	55	[1]+ .1
170	100 yards north of Old Orchard Light	5	11.10	do	19	ESE	do	5	22.7	1.0135	1,185	[1]+ .1
171	Outlet Keyport sewage disposal plant	June 25	11.15 a.m.	L. W	1	None	Fair	Slight			150	[1]− .1
172	do	25	11.15	do	1	do	do	do			50	[1]− .1
173	do	26	9.20	Ebb	2	do	Cloudy	Moderate			90	+ 1
174	do	28	6.30 p.m.	Flood	2	SW	Fair	Slight	23	1.0145	435	+10
175	do	29	6.35	do	2	SW	do	do	22.2	1.0170	160	+ 1
176	do	30	9.35 a.m.	do	2	SW	do	do	21.6	1.0175	30	
177	do	July 10	10.35	Ebb	2	S	do	Moderate	21.6	1.0090	72	+ 1
178	The Narrows, opposite Fort Wadsworth	Nov. 26	8.50	Flood	96	None	Foggy	5	6.6		75	− .01
179	Off South Beach	26	9.10	do	14	do	do	5	6.6		30	− .1
180	Off Midland Beach	26	9.30	do	16	do	do	5	6.6		50	+ .1
181	Off Elm Tree Beacon	26	9.45	do	17	do	do	5	6.6		105	+ 1
182	Two miles WSW. of Old Orchard Light	26	10.10	do	28	do	do	5	6.6		11	− 1
183	Keyport Harbor, opposite Keyport Yacht Club	26	2.50 p.m.	Ebb	10	do	Fair	10	7.2		88	+ .1
184	Keyport Channel, opposite Conaskonk Point	26	3.00	do	10	do	do	10	7.2		14	− 1
185	Channel, between Nos. 184 and 186	26	3.10	do	12	do	do	10	7.2		20	− 1
186	Black can buoy No. 3, Keyport Channel	26	3.20	do	12	do	do	5	7.2		10	+ .1
187	Between Old Orchard Light and Great Kills	26	3.35	do	17	do	do	0	7.2		45	− .1
188	Off Elm Tree Beacon	26	3.45	do	18	do	do	0	7.2		30	+ .1
189	Off Midland Beach	26	3.55	do	17	do	do	0	7.2		70	+ .1
190	Off South Beach	26	4.00	do	15	do	do	0	7.2		130	+ .1
191	The Narrows, opposite Fort Wadsworth	26	4.20	do	96	do	do	10	7.2		140	+ .1

[1] Highest dilution planted.

TABLE F.—*Samples of mud, Raritan Bay*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Mud samples.	
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.
		1915.			*Feet.*				°*C.*			*C. c.*
192	Off Conaskonk Point, northwest corner of oyster planting area.	July 14	1.55 p. m.	Ebb.....	14	None....	Fair.....	.....	.....	.....	16,000	−0.1
193	Off Conaskonk Point, 500 yards shoreward from No. 192.	14	2.05	...do.....	10	...do.....	...do.....	.....	.....	.....	22,500	− .1
194	Off Conaskonk Point, 500 yards shoreward from No. 193	14	2.10	...do.....	8	...do.....	...do.....	.....	.....	.....	1,500	− .1
195	Off Conaskonk Point, 500 yards west of the point....	14	4.55	...do.....	8	...do.....	...do.....	.....	.....	.....	10,900	− .1
196	Off Conaskonk Point, 500 yards northeast of No. 195.	14	5.05	...do.....	8	...do.....	...do.....	.....	.....	.....	1,700	− .1
197	Off Conaskonk Point, eastern end of oyster planting area.	14	5.15	...do.....	12	...do.....	...do.....	.....	.....	.....	5,800	− .1
198	Off Conaskonk Point, 500 yards east of No. 192.....	14	5.20	...do.....	14	...do.....	...do.....	.....	.....	.....	6,100	− .1
199	Off Conaskonk Point, center of oyster planting area.	14	5.30	...do.....	10	...do.....	...do.....	.....	.....	.....	32,500	− .1

TABLE G.—*Raritan Bay, Conaskonk Point (Keyport Bar).*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c. agar 37°, 48 hours.	Score based on B. coli. in shell liquor.
		1915			*Feet.*				°*C.*			*C. c.*		
200	Bed No. 43	June 24	9.00 a. m.	Ebb	8	NW	Fair[1]	Slight	18.9	1.0170	[2]5	+10	100	0
201	Bed No. 4, Marylands	24	9.05	do	5	NW	do[1]	do	18.9	1.0175	[2]21	+ 1	300	3
202	Bed No. 4, Rappahannocks	24	9.07	do	5	NW	do[1]	do	18.9	1.0175	[2]14	−10	250	4
203	Bed No. 14	24	9.15	do	8	NW	do[1]	do	19.4	1.0170	[2]14	−10	200	4
204	Bed No. 12	24	9.20	do	8	NW	do[1]	do	19.4	1.0180	[2]13	+ 1	900	3
205	Bed No. 1	24	9.30	do	9	NW	do[1]	do	19.4	1.0175	[2]14	+10	100	4
206	Bed No. 37	24	9.35	do	9	NW	do[1]	do	20	1.0181	[2]11	+ 1	200	2
207	Bed No. 37	24	9.40	do	9	NW	do[1]	do	20	1.0175	.....	.....	100	5
208	Bed No. 37, shore side	24	9.45	do	5	NW	do[1]	do	20	1.0175	.....	.....	150	5
209	Bed No. 27	24	9.55	do	9	NW	do[1]	do	20	1.0170	.....	.....	400	5
210	Bed No. 17, Delawares	24	10.00	do	10	NW	do[1]	do	20	1.0175	.....	.....	100	1
211	Bed No. 4, duplicate floated	24	10.05	do	11	NW	do[1]	do	20	1.0180	.....	.....	100	2
212	Bed No. 5	25	9.25	do	12	None	do	do	21.6	1.0175	8	+ 1	100	1
213	Bed No. 48, East Rivers	25	9.35	do	15	do	do	do	22.2	1.0175	8	−10	200	0
214	Bed No. 48, Delawares	25	9.50	do	15½	do	do	do	22.2	1.0180	5	−10	300	0
215	Bed No. 38	25	10.00	do	14	do	do	do	22.7	1.0175	7	+10	200	1
216	Bed No. 32	25	10.15	do	14	do	do	do	22.7	1.0170	8	−10	200	3
217	Bed No. 9	25	10.20	do	13	do	do	do	22.7	1.0170	9	−10	200	1
218	Bed No. 33	25	10.25	do	12	do	do	do	22.2	1.0170	9	+10	300	0
219	Bed No. 17, North Rivers	25	10.30	do	10½	do	do	do	22.7	1.0170	9	+10	700	1
220	Bed No. 43	July 19	2.00 p. m.	E. Beg.	11	SW	do	15	24.5	1.0150	25	+10	400	2
221	Bed No. 4	19	2.05	do	11	SW	do	15	24.5	1.0155	20	+10	300	1
222	Bed No. 52	19	2.10	do	11	SW	do	15	24.5	1.0155	16	+10	500	0
223	Bed No. 19	19	2.30	do	12	SW	do	15	24.5	1.0150	13	+10	500	1
224	Bed No. 12	19	2.35	do	12	SW	do	15	24.5	1.0150	68	+10	800	0
225	Bed No. 1	19	2.40	do	12	SW	do	15	24.5	1.0150	15	+10	600	0
226	Bed No. 37	19	2.45	do	12	SW	do	15	24.5	1.0150	.....	.....	700	0
227	Bed No. 17	19	2.55	do	12	SW	do	15	24.5	1.0150	20	+10	300	0
228	Bed No. 33	19	3.10	do	13	SW	do	15	24.5	1.0155	20	+10	300	2
229	Bed No. 5	19	3.15	do	14	SW	do	15	25	1.0155	16	+10	300	0
230	Bed No. 48	20	9.25 a. m.	Flood	14	NNW	do	10	22.7	1.0160	9	+10	500	3
231	Bed No. 38	20	9.35	do	15	NNW	do	10	22.7	1.0160	12	+ 1	200	3
232	Bed No. 3	20	9.55	do	13	NNW	do	10	22.7	1.0160	8	+ 1	300	1
233	Bed No. 32	20	10.00	do	14	NNW	do	10	22.7	1.0160	12	+10	300	5
234	Bed No. 6	20	10.20	do	12	NNW	do	10	22.7	1.0160	12	+10	100	0
235	Bed No. 14	20	10.35	do	12	NNW	do	10	22.7	1.0160	4	+10	200	2

237	Bed No. 48	Aug.	2	9.15	...do..	17	E.....	...do....	5.....	26	1.0135	190	+ 1	35,000	14
238	Bed No. 32		2	9.45	...do..	16	E.....	...do....	5.....	26.5	1.0120	340	[3] + .1	5,500	2
239	Bed No. 33		2	10.05	...do..	12	E.....	...do....	5.....	27	1.0120	150	[3] + .1	8,300	5
240	Bed No. 6		2	10.20	...do..	12	E.....	...do....	5.....	27	1.0120	340	[3] + .1	5,700	23
241	Bed No. 37		2	10.25	...do..	10	E.....	...do....	5.....	27	1.0120	190	+ 1	4,000	5
242	Bed No. 1		2	10.30	...do..	10	E.....	...do....	5.....	26.5	1.0120	190	[3] + .1	7,000	41
243	Bed No. 12		2	10.40	...do..	10	E.....	...do....	5.....	27	1.0120	350	+ 1	1,600	14
244	Bed No. 14		2	10.45	...do..	9	E.....	...do....	5.....	27	1.0110	290	[3] + .1	2,000	14
246	Bed No. 5		2	10.50	...do..	12	E.....	...do....	5.....	27	1.0100	350	[3] + .1	1,400	14
247	Bed No. 31		2	11.00	...do..	13	W.....	...do....	5.....	27	1.0100	210	[3] + .1	900	23
248	Bed No. 17		5	1.45 p. m.	F.Beg.	10	ESE..	...do[1]...	100..... 100.....	24	1.0065	160 [2] 248	[3] + .1 [3] + .1	21,000	50
249	Bed No. 5		5	1.55	...do..	14	ESE..	...do[1]...	100..... 100.....	24	1.0065	325 [2] 287	[3] + .1 [3] + .1	11,500	41
250	Bed No. 31		5	2.15 p. m.	Flood.	12	ESE..	...do.[1]...	100.....	23.3	1.0060	390 [2] 270	[3] + .1	8,500	41
251	Bed No. 4		5	2.30	...do..	11	ESE..	...do[1]....	100.....	24	1.0060	390 [2] 300	[3] + .1	6,600	41
252	Bed No. 43		5	2.40	...do..	8	ESE..	...do[1]....	100.....	24	1.0060	390	[3] + .1	8,800	50
253	Bed No. 25		5	2.50	...do..	12	ESE..	...do[1]....	100.....	24	1.0060	300 [2] 450	[3] + .1	11,400	41
254	Bed No. 12		5	2.55	...do..	8	ESE..	...do[1]....	100.....	24	1.0060	450	[3] + .1	5,200	41
255	Bed No. 14		5	3.00	...do..	8	ESE..	...do[1]....	100.....	24	1.0060	450	[3] + .1	5,700	41
256	Conaskonk Point, sample of 300 brought in and deposited in Lupatcong Creek for observation.		6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500	14
257	.....do		6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	400	23
258	L. Mason's bed, duplicate floated in Lupatcong Creek.		18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	800	23
259	Bed No. 37	Nov.	17	8.35 a. m.	Ebb..	6	NW...	Cloudy[4].	5.....	5.5	1.0200	[2] 17	+ 1	200	5
260	Bed No. 1		17	9.05	...do..	6	NW...	...do[4]....	5.....	6.1	1.0200	[2] 18	+ 1	50	0
261	Bed No. 12		17	9.15	...do..	6	NW...	...do[4]....	5.....	6.1	1.0190	[2] 20	[3] + .1	60	2
262	Bed No. 14		17	9.20	...do..	6	NW...	...do[4]....	5.....	6.6	1.0190	.....	.....	100	4
263	Bed No. 7		18	10.20	...do..	11	None..	Fair.....	5.....	6.6	1.0200	[2] 11	+10	1,400	5
264	Bed No. 16		18	10.30	...do..	8	...do..	...do.....	5.....	6.6	1.0200	[2] 10	+10	3,750	2
265	Bed No. 33		18	10.40	...do..	8	...do..	...do.....	5.....	7.2	1.0195	[2] 11	+ 1	275	2
266	Bed No. 48		18	11.15	.do..	14	...do..	...do.....	5.....	7.2	1.0190	[2] 14	+10	5,100	2
267	Bed No. 27		18	11.30	...do..	4	...do..	...do.....	5.....	7.7	1.0190	[2] 12	+10	380	4
268	Bed No. 28		18	11.50	...do..	4	...do..	...do.....	5.....	7.7	1.0190	[2] 12	+ 1	3,800	3
269	Bed No. 1, outer edge		18	12.05 p. m.	...do..	10	...do..	...do.....	5.....	7.7	1.0190	[2] 21	+10	5,200	14
270	Bed No. 23		18	12.10	...do..	8	...do..	...do.....	5.....	7.7	1.0190	[2] 19	+ 1	1,350	1
271	Bed No. 31		18	12.20	Low water.	14	...do..	...do.....	5.....	7.7	1.0190	[2] 14	−10	550	1
272	Bed No. 32		23	2.30	Ebb...	14	SW...	Cloudy..	5.....	6.1	1.0185	16	+ 1	110	0
273	Bed No. 33		23	2.40	...do..	10	SW...	...do.....	5.....	6.1	1.0185	9	+ 1	60	2
274	Bed No. 27		23	2.40	...do..	10	SW...	...do.....	5.....	6.1	1.0185	22	+ 1	350	1
275	Bed No. 37		23	3.00	...do..	6	SW...	...do.....	5.....	6.1	1.0185	23	+ 1	370	1
276	Bed No. 1		23	3.10	...do..	7	SW...	Fair.....	5.....	6.1	1.0180	18	+ 1	380	1

[1] Following stormy weather.

[2] From bottom.

[3] Highest dilution planted.

[4] Following heavy wind.

TABLE G.—*Raritan Bay, Conaskonk Point (Keyport Bar)*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
277	Bed No. 14	Nov. 23	3.15 p.m.	Ebb	6	SW	Fair	5	6.1	1.0185	27	+10	350	2
278	Bed No. 31	23	3.25	do	7	SW	do	5	6.1	1.0180	17	+ 1	.....	.....
279	Bed No. 4	23	3.30	do	7	SW	do	5	6.1	1.0180	16	+ 1	150	5
280	Bed No. 43	23	3.30	do	7	SW	do	5	6.1	1.0180	.....	.....	160	3
		1916.												
281	Hammer's bed	June 9	11.00 a.m.	do	(1)	NE	Cloudy	.....	.....	.....	.....	+ 1	.....	5
282	do	9	11.00	do	(1)	NE	.....	.....	.....	.....	.....	+ 1	.....	4
283	Maurer's bed	9	11.00	do	(1)	NE	Cloudy	.....	.....	.....	.....	+ 1	.....	3
284	do	9	11.00	do	(1)	NE	.....	.....	.....	.....	.....	− 1	.....	5
285	Wylie's bed	9	11.00	do	(1)	NE	.....	.....	.....	.....	.....	− 1	.....	14
286	do	9	11.00	do	(1)	NE	.....	.....	.....	.....	.....	+ 1	.....	32
287	do	15	6.00 p.m.	Flood	.....	NE	Clear	.....	.....	.....	.....	.....	.....	1

[1]Surface.

TABLE H.—*Matawan Creek.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water samples.	
											Number colonies per c. c., agar 37° 48 hours.	B. coli.
		1915.			*Feet.*				°*C.*			*C. c.*
288	Mouth	June 25	11.20 a. m.	Low water.	3	None	Fair	Slight			110	+ 1
289	....do	26	9.15	Ebb	5	...do	Cloudy[1]	Moderate			220	[2] + .1
290	Above highway bridge at Matawan	Nov. 26	1.45 p. m.	...do	2	...do	Fair	50	5		30	− .1
291	Below highway bridge at Matawan	26	1.50	...do	2	...do	...do	50	5		35	− .1
292	Below fertilizer factory	26	1.55	...do	2	...do	...do	50	5		50	+ 1
293	Below trolley bridge	26	2.05	...do	5	...do	...do	40	5		35	+ 1
294	Mouth	26	2.15	...do	5	...do	...do	40	5		70	+ 1

[1] Following rain.

[2] Highest dilution planted.

69263°—17——7

TABLE I.—*Lupatcong Creek.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c. 7 agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
54	Below highway bridge, duplicate sample from bed No. 4, Conaskonk Point, floated one low tide.	June 25	11:30 a. m.	L. w...	1	None..	Fair.....	Slight.....	.....	.....	.....	.....	400	32
55	Maurer's floating ground, below bridge, floated two weeks.	25	11:30	...do...	1	...do...	...do.....	.....do.....	.....	.....	.....	.....	200	5
56	Opposite Sundergard's boathouse, "naturals."	25	11.50	...do...	1	...do...	...do.....	.....do.....	.....	.....	.....	.....	100	4
57	Hammer's floating ground, floated one low tide, brought to the laboratory by Mr. Hammer.	July 2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	350	41
58	Mason's floating ground, above bridge, floated one low tide.	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4,900	23
59	Hammer's floating ground, below bridge, floated one tide.	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,300	50
60	Opposite Sundergard's boathouse, "naturals."	Aug. 6	10.15 a. m.	L. w...	2	E.....	Cloudy[1].	40.....	19.4	1.0020	80	+10	1,900	14
61	Below highway bridge, duplicate sample from bed No. 25, Conaskonk Point, floated one low tide.	6	10.30	F. beg.	2½	E.....	...do[1]...	100.....	19.4	1.0025	410	[2]+ .1	13,800	32
62	Below highway bridge, duplicate sample from bed No. 12, Conaskonk Point, floated one low tide.	6	10.30	...do...	2½	E.....	...do[1]....	100.....	19.4	1.0025	.....	.....	7,000	5
63	Above highway bridge, floated one low tide.	6	10.20	...do...	2½	E.....	...do[1]....	100.....	19.4	1.0025	160	+ 1	9,000	32
64	Below highway bridge, sample from 300 Conaskonk Point oysters deposited for observation Aug. 5, 1915, floated two low tides.	7	12.00 m.	...do...	2	SW...	Fair[1]...	100.....	.....	.....	.....	.....	1,000	140
65	.....do.....	7	12.00	...do...	2	SW...	...do[1]....	100.....	.....	.....	100	[2]+ .1	2,500	230
66	Below highway bridge, sample from oysters deposited for observation, floated six low tides.	9	2.00 p. m.	...do...	2	SW...	...do[1]....	100.....	32.2	1.0075	1,170	[2]+ .1	2,100	140
67	.....do.....	9	2.00	...do...	2	SW...	...do[1]....	100.....	32.2	1.0075	.....	.....	23,000	410
68	Below highway bridge, sample from oysters deposited for observation, floated eight low tides.	10	2.30	E. last.	2	NW..	...do.....	.....	.....	.....	.....	.....	1,400	50

69	Below highway bridge, floated two low tides.		19	12.15	Flood	4	NW	...do	10	22.2	1.0115	70	+ 1	1,100	23
70	.....do		19	12.20	...do	6	NW	...do	10	22.2	1.0120	98	+ 1	1,100	50
71	Above highway bridge, floated two tides.		19	12.30	...do	5	NW	...do	10	22.2	1.0120	100	+ 1	600	50
72	Below Ellsworth's shucking house, floated two tides.		19	12.35	...do	5	NW	...do	10	22.2	1.0120	108	[2] + .1	500	50
73	Ellsworth's shucking house, floated	Nov.	16	2.00										400	41
74	.....do		16	2.00										500	23
75	.....do		16	2.00										350	5
76	.....do		16	2.00										3,050	50
77	.....do		16	2.00										400	32
78	.....do		16	2.00										650	23
79	.....do		16	2.00										2,900	41
			1916												
80	Conaskonk Bar, floated 4 days	June	12	11.30 a. m.	Ebb	[3]	NW	Clear					+ .1		140
82	Ellsworth's shucking house float		13	2.50 p. m.	Flood		W	...do					+ .1		230
83	Maurer float, floated 5 days		13	3.15	...do	[3]	W	...do					+ .01		500
84	Wylie's Conaskonk bar, floated 18 hours, Maurer's float.		15	12.00 m.	Ebb	[3]	E	Cloudy					+ .1		1

[1] Following stormy weather.

[2] Highest dilution planted.

[3] Surface.

TABLE J.—*Lupatcong Creek.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water samples.	
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.
		1915.			*Feet.*				°*C.*			*C. c.*
1	Mouth	June 25	11.25 a.m.	L.w.	1	None	Fair	Slight			50	+ 1
2	Above highway bridge	25	11.40	do	1	do	do	do			60	+ 1
3	Mouth of storm sewer above Ellsworth's shucking house.	25	11.50	do	1	do	do	do			40	+10
4	75 yards above No. 3	25	11.55	do	1	do	do	do			90	−10
5	Sundergard's boathouse	25	12.00 m.	do	1	do	do	do			100	−10
6	do	26	9.00 a.m.	Ebb	2	do	Cloudy	Moderate			188	[1]+ .1
7	Mouth of storm sewer	26	9.05	do	2	do	do	do			150	[1]+ .1
8	Below highway bridge	26	9 08	do	2	do	do	do			138	[1]+ .1
9	Mouth	26	9.10	do	3	do	do	do			168	[1]+ .1
10	Sundergard's boathouse	28	6.00 p.m.	F. last	3	SW	Fair	Slight	25.0	1.0150	80	[1]+ .1
11	Mouth of storm sewer	28	6.10	do	3	SW	do	do	23.8	1.0155	75	[1]+ .1
12	Above highway bridge	28	6.15	do	4	SW	do	do	25.0	1.0150	42	[1]+ .1
13	Mouth	28	6.20	do	5	SW	do	do	24.4	1.0155	74	[1]+ .1
14	Sundergard's boathouse	29	6.15	do	3	SW	do	do	23.3	1.0160	25	+ 1
15	Mouth of storm sewer	29	6.20	do	3	SW	do	do	22.7	1.0165	37	+10
16	Below highway bridge	29	6.25	do	5	SW	do	do	22.7	1.0165	38	+10
17	Mouth	29	6.30	do	5	SW	do	do	22.7	1.0170	20	+ 1
18	Sundergard's boathouse	30	8.30 a.m.	do	3	SW	do	do	21.6	1.0180	36	.....
19	Mouth of storm sewer	30	8.35	do	3	SW	do	do	21.6	1.0180	37	.....
20	Below highway bridge	30	8.45	do	5	SW	do	do	21.6	1.0180	34	.....
21	Mouth	30	9.00	do	5	SW	do	do	21.6	1.0175	38	.....
22	Sundergard's boathouse	July 1	5.00 p.m.	L. w.	1	None	do [2]	Heavy			480	[1]+ .1
23	Mouth of storm sewer	1	5.10	F. beg	1	do	do [2]	do			290	[1]+ .1
24	Above highway bridge	1	5.15	do	4	do	do [2]	do			290	[1]+ .1
25	Storm sewer at culvert	1	5.12	do	3	do	do [2]	do			250	[1]+ .1
26	Mouth	1	5.25	do	5	do	do [2]	do			245	[1]+ .1
27	Sundergard's boathouse	2	6.00	do	3	NE	Rainy	Moderate			71	[1]+ .1
28	Mouth of storm sewer	2	6.45	do	3	NE	do	do			168	[1]+ .1
29	Under Ellsworth's shucking house	10	10.20 a.m.	Ebb	2	S	Fair	do	21.6	1.0065	203	+ 1
30	Under highway bridge	10	10.25	do	3	S	do	do	21.1	1.0070	230	[1]+ .1
31	Mouth	10	10.28	do	4	S	do	do	21.6	1.0095	178	[1]+ .1
32	Sundergard's boathouse	17	12.10 p.m.	do	2	NW	do	30	26.6	1.0140	310	[1]+ .1
33	Mouth of storm sewer	17	12.15	do	2	NW	do	30	26.1	1.0140	390	+ 1
34	Under highway bridge	17	12.17	do	3	NW	do	30	26.6	1.0135	145	[1]+ .1
35	Mouth	17	12.20	do	4	NW	do	30	26.6	1.0135	190	[1]+ .1
36	Sundergard's boathouse	20	3.00	E. beg	3	NE	Cloudy [2]	Moderate	23.3	1.0150	110	+ 1

37	Mouth of storm sewer		20	3.05	...do.....		3	NE.....	...do [2]...	.....do.....	23.3	1.0150	110	[1] + .1
38	Above highway bridge		20	3.10	...do.....		4	NE.....	...do [2]...	.....do.....	23.3	1.0150	100	[1] + .1
39	Mouth		20	3.15	...do.....		5	NE.....	...do [2]...	.....do.....	23.8	1.0150	80	[1] + 1
40	Mouth of storm sewer	Aug. 6		10.25 a.m.	L. w...		1	E.....	...do [2]...	60.....	19.4	1.0025	150	+ 1
41	Sundergard's boathouse		7	11.50	...do.....		1	SW.....	Fair [2]...	60.....	.....	.....	20	+10
42	Mouth of storm sewer		7	11.55	...do.....		1	SW.....	...do [2]...	60.....	.....	.....	45	−10
43	Sundergard's boathouse		9	1.45 p.m.	F. beg..		3	SW.....	...do [2]...	100.....	27.7	1.0050	370	[1] + .1
44	Mouth of storm sewer		9	1.50	...do.....		3	SW.....	...do [2]...	100.....	27.2	1.0050	1,100	[1] + .1
45	Above highway bridge		9	1.55	...do.....		4	SW.....	...do [2]...	100.....	26.6	1.0070	900	[1] + .1
46	Sundergard's boathouse		10	2.30	E. last..		1	NW.....	...do.....	.....	.....	.....	270	+ 1
47	Mouth of storm sewer		10	2.30	...do.....		1	NW.....	...do.....	.....	.....	.....	120	+ 1
48	Above highway bridge		10	2.30	...do.....		2	NW.....	...do.....	.....	.....	.....	180	+ .1
49	Below highway bridge		10	2.30	...do.....		2	NW.....	...do.....	.....	.....	.....	190	[1] + .01
50	.....do		18	9.00 a.m.	F. beg..		2	NW.....	...do.....	20.....	20.5	1.0100	75	−10
51	.....do		18	9.05	...do.....		2	NW.....	...do.....	20.....	20	1.0080	320	[1] + .1
52	Above highway bridge		18	9.10	...do.....		2	NW.....	...do.....	20.....	20	1.0090	345	[1] + .1
53	Below Ellsworth's shucking house		18	9.15	...do.....		2	NW.....	...do.....	20.....	20	1.0090	290	+ 1
		1916.												
81	Off Ellsworth's shucking house	June 12		11.35 a.m.	Ebb.....	[3]		NW.....	Clear.....	.....	.....	.....	.....	+ .1
85	Beatties Landing		13	3.05 p.m.	Flood...	[3]		W.....	...do.....	.....	.....	.....	.....	+ .1
86	About 100 feet above Ellsworth's		15	12 30	Ebb.....	[3]		E.....	Cloudy..	.....	.....	.....	.....	− 1
87	Culvert, Beers Street, 250 feet above Ellsworth's		15	12.40	...do.....	[3]		E.....	...do.....	.....	.....	.....	.....	− 1
88	Elizabeth Street Bridge		15	12.55	...do.....	[3]		E.....	...do.....	.....	.....	.....	.....	+ 1
89	1,000 feet below railroad		15	1.05	...do.....	[3]		.....	.....	.....	.....	.....	.....	− 1
90	100 yards above railroad		15	1.30	...do.....	[3]		.....	.....	.....	.....	.....	.....	− 1

[1] Highest dilution planted.

[2] Following stormy weather.

[3] Surface.

TABLE K.—*Cheesequake Creek.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
1	Upper float	June 26	9.15 a. m.	Ebb	8	E	Rain	Moderate	20.5	1.0155	175	+1		
2	Above upper floating ground	26	9.20	do	8	E	do	do	20.5	1.0130	116	+1		
3	Lower float	July 2	1.00 p. m.	H. w.	10	NE	Cloudy	Slight	22.7	1.0170	26	+1		
4	Middle float	2	1.10	E. beg.	10	NE	do	do	22.7	1.0170	19	+1		
5	Upper float	2	1.20	do	8	NE	do	do	22.7	1.0170	21	+1		
6	Middle float	2	7.20	Flood	9	NE	do	Moderate	22.2	1.0115	75	+1		
7	Float below brickyard	June 26	8.55 a. m.	Ebb	8	E	Rain	do	21.1	1.0170	98	+1	100	1
8	Wm. Wooley floating ground	26	9.10	do	10	E	do	do	21.1	1.0160	108	+1	100	2
9	Lower float	July 2	7.15 p. m.	Flood	10	NE	Cloudy	do	22.7	1.0125	66	+1	100	14
10	Upper float	2	7.30	do	8	NE	do	do	22.1	1.0120	58	+1	100	3
		1916.												
11	Mouth Cheesequake Creek	June 12	2.00	do	(1)	NW	Clear					−1		
12	Between two drawbridges	12	2.00	do		NW	do					−1		
13	Opposite raceway	12	2.20	do	(1)	NW	do					+1		
14	Opposite brickyard	12	2.40	do	(1)	NW	do					−1		
15	Lower floating grounds	12	3.00	do		NW	do					+1		
16	Upper floating grounds, floated Conaskonk salts.	12	3.10	do	(1)	NW	do					+1		23
17	Head	12			(1)	NW	do					−1		
18	Head near Long Wharf	14	12.30 p. m.	H. w.	(1)	NE	do					−1		
19	Just below manure wharf	14	12.40	do	(1)	NE						−1		
20	Just below Perrin's dock	14	12.45	do	(1)	NE	Clear					+1		
21	Near high dock, east shore, upper floating grounds.	14	12.50	do	(1)	NE	do					+ .1		
22	Lower floating grounds, from Conaskonk Bar, floated 4 days.	14	1.00	E. beg.	(1)	NE	do					+1		3
23	Floating ground, just above brickyard	14	1.10	do	(1)	NE	do					+1		
24	Mouth of raceway	14	1.20	do	(1)	NE	do					+1		

[1] Surface.

TABLE L.—*Navesink River.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
1	Off steamboat wharf at Fairhaven	July 7	4.00 p. m.	Flood	4	SE	Fair	0	25.0	1.0130	37	+ 1	900	1
2	do	7	4.10	do	6	SE	do	0	23.9	1.0130	38	+10	500	2
3	Off eastern shore at Fairhaven	7	4.20	do	4	SE	do	0	24.3	1.0128	124	+10	700	1
4	Middle of river, opposite mouth McClees Creek.	7	4.30	do	6	SE	do	0	23.9	1.0135	57	+10	300	2
5	Off western shore, below mouth McClees Creek.	7	4.35	do	5	SE	do	0	23.9	1.0115	71	+10	1,100	2
6	Off eastern shore, at Lewis Point	7	4.40	do	5	SE	do	0	23.9	1.0120	68	+10	300	3
7	Off western shore, above mouth McClees Creek.	7	4.45	do	5	SE	do	0	23.9	1.0120	76	+ 1	1,500	23
8	100 yards off Robins Point	8	9.00 a. m.	Ebb	4	S	Cloudy	0	22.7	1.0095	17	[1] + .1	400	3
9	Off McClures Point	8	9.25	do	8	S	do	0	22.7	1.0120	18	+10	700	4
10	do	8	9.25	do	8	S	do	0	22.7	1.0120			200	0
11	Walter Minton bed	8	9.35	do	8	S	do	0	23.3	1.0120	18	+10	1,200	23
12	Off Guyon Point	8	9.50	do	8	S	do	0	22.7	1.0115	30	+ 1	1,300	4
13	Off eastern shore at Fairhaven, opposite Chandler residence.	30	8.00	L. w.	4	W	Fair	0	26.6	1.0140	176	+ 1	700	3
14	Off eastern shore at Fairhaven above No. 13.	30	8.30	do	4	W	do	0	26.6	1.0140			2,400	32
15	Middle of river, opposite steamboat wharf at Fairhaven.	30	9.00	F. beg.	8	W	do	0	26.6	1.0150	164	+ 1	5,400	32
16	Off McClees Point	30	9.15	do	3	W	do	0	26.6	1.0140	76	[1] + .1	1,300	2
17	Off Lewis Point	30	9.30	do		W	do	0	26.1	1.0140	126	+10	1,100	3
18	Mouth McClees Creek floating ground	30	9.25	do	2	W	do	5	27.2	1.0125	225	+ 1		
19	Walter Minton bed	30	9.45	Flood	6	W	do	0	27.7	1.0140	290	+ 1	300,000	4
20	Off Robins Point	30	10.25	do	4	W	do	0	28.3	1.0110	198	[1] + .1	700	3
21	Between old railroad and highway bridge, north side.	30	10.40	do	4	W	do	0	28.3	1.0165	173	+ 1	3,200	23
22	200 yards off Guyon Point	30	11.00	do	8	None	do	0	28.3	1.0120	156	+ 1	900	5
23	Mouth Red Bank sewage disposal plant.	30	10.35	do	8	W	do	0	28.3	1.0125	380	+ 1		

[1] Highest dilution planted.

TABLE M.—*Shrewsbury River.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
1	Pleasure Bay, above Shallow Point	July 9	9.30 a. m.	Ebb	2½	NW	Fair	Moderate	21.1	1.0140	183	+ 1	600	23
2	Mouth Pleasure Bay, below Shallow Point, soft clams.	9	9.45	do	5	NW	do	do	21.1	1.0140	40	+10	400	2
3	Mouth of Little Silver Creek	9	10.00	do	3	NW	do	do	22.1	1.0130	155	+ 1	500	3
4	Below Red Light, above Gunning Island, hard clams.	9	10.30	do	5	NW	do	do	21.1.	1.0155	7	+10	400	3
5	Pleasure Bay, above Shallow Point	30	2.40 p. m.	do	2	St	do	0	29.4	1.0125	265	+ 1	9,700	14
6	Pleasure Bay, off Patten Point, soft clams.	30	2.30	do	2	SE	Cloudy	0	29.4	1.0125	410	[1] + .1	1,200	1
7	Mouth of Blackberry Creek	30	3.12	do	5	SE	Fair	0	28.3	1.0140	85	+10	800	2

[1] Highest dilution planted.

TABLE N.—*Atlantic coast of New Jersey.*[1]

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Water, B. coli.	Shellfish, score based on B. coli shell liquor.
		1915.						*C. c.*	
1	Jenkins Sound, northeast part	Aug. 20	3.00 p. m.	H. W.	Surface.	None	Fair		2
2	Swains Channel, between Wildwood and Cape May, 1,000 yards from mouth	21	8.30 a. m.	Ebb	do	SE	Cloudy		1
3	Richardsons Channel, just off inland waterway route	21	8.30	do	do	SE	do		2
4	100 yards below Wildwood wagon bridge	21	9.00	do	do	SE	do		4
5	Taylors Sound	21	9.00	do	do	SE	do		2
6	300 yards below Wildwood Bridge—in branch off channel	21	9.30	do	do	SE	do		14
7	Eastern side of Lakes Bay, near Ventnor Canal	25	9.30	do	do	W	Fair		1
8	Western shore Lakes Bay; second oyster house below boulevard	25	10.00	do	do	W	do		[2] 0
9	Third oyster house below boulevard on western shore Lakes Bay	25	10.00	do	do	W	do		0
10	First oyster house below boulevard, Lake's Bay (western shore)	25	10.00	do	do	W	do		4
11	Sheepshank Thoroughfare (Absecon)	27	11.00	do	do	NE	Cloudy		0
12	do	27	11.00	do	do	NE	do		2
13	Absecon Creek	27	11.00	do	do	NE	do		2
14	do	27	11.00	do	do	NE	do		1
15	do	27	11.00	do	do	NE	do		0
16	Jenkins Sound	20	3.00	H. W.	do	None	Fair	−1	
17	do	20	3.00	do	do	do	do	−1	
18	do	20	3.00	do	do	do	do	−1	
19	do	20	3.00	do	do	do	do	−1	
20	do	20	3.00	do	do	do	do	−1	
21	do	20	3.00	do	do	do	do	−1	
22	do	20	3.00	do	do	do	do	−1	
23	do	20	3.00	do	do	do	do	−1	
24	do	20	3.00	do	do	do	do	−1	
25	do	20	3.00	do	do	do	do	−1	
26	Grassy Sound, at intervals	20	3.00	do	do	do	do	−1	
27	do	20	3.00	do	do	do	do	−1	
28	do	20	3.00	do	do	do	do	−1	
29	do	20	3.00	do	do	do	do	+ .1	
30	do	20	3.00	do	do	do	do	+1	
31	do	20	3.00	do	do	do	do	+ .01	
32	do	20	3.00	do	do	do	do	+ .1	
33	do	20	3.00	do	do	do	do	+1	
34	do	20	3.00	do	do	do	do	+1	
35	do	20	3.00	do	do	do	do	+ .1	
36	Jarvis Sound	21	8.00	Ebb	do	SE	Cloudy	−1	
37	do	21	8.00	do	do	SE	do	−1	
38	do	21	8.00	do	do	SE	do	−1	
39	do	21	8.00	do	do	SE	do	−1	
40	do	21	8.00	do	do	SE	do	−1	
41	Taylors Sound near Hann's oyster beds. (Sample No. 22 S)	21	8.30	do	do	SE	do	−1	
42	do	21	8.30	do	do	SE	do	−1	

[1] Showing results obtained from samples of shellfish and water collected by the Public Health Service and New Jersey Board of Health.

[2] Presumptive test, 230.

TABLE N.—*Atlantic coast of New Jersey*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Water, B. coli.	Shellfish, score based on B. coli shell liquor.
		1915.							
43	Taylors Sound near Hann's oyster beds. (Sample No. 22 S)	Aug. 21	8.30 a.m.	Ebb	Surface	SE	Cloudy	−1	
44	do	21	8.30	do	do	SE	do	+1	
45	do	21	8.30	do	do	SE	do	−1	
46	Vicinity of Wildwood wagon bridge, along inland waterway	21	10.00	do	do	SE	do	−1	
47	do	21	10.00	do	do	SE	do	+ .1	
48	do	21	10.00	do	do	SE	do	+ .1	
49	do	21	10.00	do	do	SE	do	+ .1	
50	do	21	10.00	do	do	SE	do	+ .1	
51	do	21	10.00	do	do	SE	do	+ .1	
52	do	21	10.00	do	do	SE	do	+1	
53	do	21	10.00	do	do	SE	do	+ .1	
54	do	21	10.00	do	do	SE	do	+ .1	
55	do	21	10.00	do	do	SE	do	+1	
56	Lakes Bay, near center	25	9.30	do	do	W	Fair	−1	
57	do	25	9.30	do	do	W	do	−1	
58	do	25	9.30	do	do	W	do	−1	
59	do	25	9.30	do	do	W	do	−1	
60	do	25	9.30	do	do	W	do	−1	
61	From ditch over Mr. Mather's float, Lakes Bay	25	10.00	do	do	W	do	−1	
62	do	25	10.00	do	do	W	do	+1	
63	do	25	10.00	do	do	W	do	+ .1	
64	do	25	10.00	do	do	W	do	+ .1	
65	do	25	10.00	do	do	W	do	+1	
66	In ditch in which J. Hilton's float is located, Lakes Bay	25	10.30	do	do	W	do	−1	
67	do	25	10.30	do	do	W	do	+1	
68	do	25	10.30	do	do	W	do	−1	
69	do	25	10.30	do	do	W	do	+ .1	
70	do	25	10.30	do	do	W	do	+ .1	
71	In ditch flowing over Mr. Fish's float, Lakes Bay	25	10.30	do	do	W	do	−1	
72	do	25	10.30	do	do	W	do	+1	
73	do	25	10.30	do	do	W	do	−1	
74	do	25	10.30	do	do	W	do	−1	
75	do	25	10.30	do	do	W	do	+1	
76	Absecon Creek	27	11.00	do	do	NE	Cloudy	−1	
77	do	27	11.00	do	do	NE	do	−1	
78	do	27	11.00	do	do	NE	do	+1	
79	do	27	11.00	do	do	NE	do	−1	
80	do	27	11.00	do	do	NE	do	−1	
81	do	27	11.00	do	do	NE	do	−1	
82	do	27	11.00	do	do	NE	do	−1	
83	do	27	11.00	do	do	NE	do	−1	
84	do	27	11.00	do	do	NE	do	−1	
85	do	27	11.00	do	do	NE	do	−1	

TABLE O.—*Little Egg Harbor.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
1	J. W. Parker & Bros. shipping house, oysters from Tuckerton Bay, "Inlet." [1]	Dec. 13	10.00 a. m.	.....	.....	.....	.....	.....	.....	.....	.....	.....	270	3
2	Parker Bros. float, Tuckerton Creek [1]	13	10.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	105	23
3	George Quinn float, Tuckerton Creek.[1]	13	10.10	Ebb..	.....	NW...	Stormy.	0	.....	.....	.....	.....	310	32
4	D. A. Mathis float, Tuckerton Creek [1]	13	10.15	...do...	.....	NW...	...do....	.....	.....	.....	.....	.....	210	5
5	W. S. Allen float, Tuckerton Creek [1]	13	10.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	225	14
6	Austin & Styles float, Tuckerton Creek.[1]	13	10.30	Ebb...	.....	NW...	Stormy.	0	.....	.....	.....	.....	225	3
7	.....do.[1]	13	10.35	...do...	.....	NW...	...do....	.....	.....	.....	.....	.....	275	4
8	Arnold Cramer float, Tuckerton Creek.[1]	13	10.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	335	4
9	.....do.[1]	13	10.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	230	3
10	.....do.[1]	13	10.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	230	23
11	Float, West Creek [1]	14	8.00	Ebb...	.....	NW...	Fair.....	0	0.0	.....	.....	.....	380	0
12	.....do.[1]	14	8.10	...do...	.....	NW...	...do....	0	0.0	.....	.....	.....	180	1
13	.....do.[1]	14	8.15	...do...	.....	NW...	...do....	0	0.0	.....	.....	.....	1,800	0
14	.....do.[1]	14	8.20	...do...	.....	NW...	...do....	0	0.0	.....	.....	.....	1,450	0
15	.....do.[1]	14	8.25	...do...	.....	NW...	...do....	0	0.0	.....	.....	.....	270	3
16	Tuckerton Creek, opposite Parker Bros. float.[1]	15	8.30	...do...	.....	NW...	...do....	0	0.0	.....	270	+ 1	.....	.....
17	Tuckerton Creek, opposite Mathis float.[1]	15	8.35	...do...	.....	NW...	...do....	0	0.0	.....	43	+10	.....	.....
18	Tuckerton Creek, opposite Cramer float.[1]	15	8.45	...do...	.....	NW...	...do....	0	0.0	.....	133	+10	.....	.....
19	Tuckerton Creek, ½ mile below dam at Tuckerton.[1]	15	9.05	...do...	.....	NW...	...do....	0	0.0	.....	80	+ 1	.....	.....
20	Tuckerton Creek, 100 feet below dam[1]	15	9.20	...do...	.....	NW...	...do....	0	0.0	.....	180	+10	.....	.....
21	West Creek, opposite lower floats [1]	15	1.15 p. m.	...do...	.....	NW...	...do....	0	0.55	.....	150	+ 1	.....	.....
22	West Creek, opposite middle floats [1]	15	1.20	...do...	.....	NW...	...do....	0	0.55	.....	92	+ 1	.....	.....
23	West Creek, opposite upper floats [1]	15	1.25	...do...	.....	NW...	...do....	0	0.55	.....	119	−10	.....	.....
24	West Creek, ½ mile above upper floats.[1]	15	1.35	...do...	.....	NW...	...do....	0	1.1	.....	340	+10	.....	.....
25	West Creek, at mouth of small branch below town of West Creek.[1]	15	1.45	...do...	.....	NW...	...do....	0	1.1	.....	810	[2]+ .1	.....	.....

[1] The above samples were shipped from Tuckerton to Maurice River, N. J. before they were examined, the weather being very cold at the time.

[2] Highest dilution planted.

TABLE P.—*Barnegat Bay.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Oysters.	
											Number colonies per c. c., agar 37° 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			
1	Barnegat Creek [1]	Dec. 14									175	0
2	.....do.[1]	14									130	0
3	.....do.[1]	14									280	3
4	.....do.[1]	14									860	2
5	.....do.[1]	14									170	2

[1] These samples were taken from a batch of oysters which had been floated about one month in Barnegat Creek. They were shipped from Tuckerton, N. J., to Maurice River, N. J., before being examined, the weather at the time being very cold.

TABLE Q.—*Delaware River above Reedy Island.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.			Dissolved oxygen, parts per million.		
											Number colonies per c. c. agar 37° 48 hours.	B. coli.	Per cent saturation.	At once.	24 hours at 20°.	Loss.
		1915.			*Feet.*				°*C.*			*C. c.*				
1	Torresdale, New Jersey side	Aug. 24	10.20 a. m.	Flood.	14	SW	Fair	0	23.8		[1] 500	[2] +0.1	82.9	7.10		
2	Torresdale, mid-channel	24	10.25	do	25	SW	do	0	23.8		[1] 143	[2] + .1	82.9	7.10	[1] 0.50	6.60
													85.2	7.30	7.00	.30
3	Torresdale, Pennsylvania side	24	10.30	do	10	SW	do	5	23.8		600	[2] + .1	82.9	7.10	7.10	.0
4	Bridesburg, Pennsylvania side	24	11.10	do	12	SW	do	50	23.8		10,000	[2] + .01	57.1	4.90	4.10	.80
5	Bridesburg, mid-channel	24	11.15	do	30	SW	do	50	23.8		[1] 1,140	.1	79.4	6.80	[1] 5.90	.90
													78.2	6.70	6.70	.0
6	Bridesburg, New Jersey side	24	11.20	do	28	SW	do	30	23.8		3,800	[2] + .01	75.9	6.50	6.40	.10
7	Coopers Point, New Jersey side	24	12.05 p. m.	do	16	SW	do	100	23.8		6,400	[2] + .001	35.0	3.00	2.20	.80
8	Coopers Point, mid-channel	24	12.10	do	30	SW	do	100	23.8		[1] 3,200	[2] + .001	39.7	3.40	[1]	
													38.5	3.30	2.90	.40
9	Coopers Point, Pennsylvania side	24	12.15	do	47	SW	do	100	23.8		11,300	[2] + .001	29.2	2.50	1.90	.60
10	Kaighn Point, New Jersey side	24	12.40	do	36	SW	do	100	23.8		4,700	[2] + .001	26.8	2.30	2.30	.0
11	Kaighn Point, mid-channel	24	12.45	do	30	SW	do	100	23.8		[1] 4,600	[2] + .001	24.5	2.10	[1] 1.50	.60
													22.1	1.90	1.10	.80
12	Kaighn Point, Pennsylvania side	24	12.50	do	31	SW	do	100	23.8		9,700	[2] + .001	11.6	1.00	1.00	.0
13	Gloucester Point, Pennsylvania side.	24	1.10	do	43	SW	do	75	23.8		37,000	[2] + .001	16.3	1.40	.80	.60
14	Gloucester Point, mid-channel	24	1.15	do	43	SW	do	75	23.8		[1] 16,000	[2] + .001	19.8	1.70	[1]	
													18.6	1.60	1.10	.50
15	Gloucester Point, New Jersey side	24	1.20	do	17	SW	do	75	23.8		6,500	+ .01			1.60	
16	League Island, New Jersey side	24	1.45	do	22	SW	do	80	23.8		1,400	+ .01	31.5	2.70	2.30	.40
17	League Island, mid-channel	24	1.50	do	37	SW	do	80	23.8		[1] 2,200	+ .01	19.8	1.70	[1] 1.20	.50
													18.6	1.60	1.50	.10
18	League Island, Pennsylvania side	24	2.00	F. last.	33	SW	do	30	24.4		12,600	[2] + .001	22.4	1.90	1.10	.80
19	Mifflin Bar, New Jersey side	24	2.30	E. beg.	24	SW	do	10	24.4		1,150	[2] + .01	36.6	3.10	2.50	.60
20	Mifflin Bar, mid-channel	24	2.35	do	36	SW	do	10	24.4		[1] 1,180	[2] + .01	30.6	2.60	[1] 2.00	.60
													39.6	2.50	2.10	.40
21	Mifflin Bar, Pennsylvania side	24	2.40	do	31	SW	do	10	24.4		3,700	[2] + .01	24.7	2.10	1.70	.40
22	Tinicum Island, New Jersey side	25	11.30 a. m.	Flood.	20	W	do	75	24.4		3,800	+ .01	28.3	2.40	2.10	.30
23	Tinicum Island, mid-channel	25	11.37	do	33	W	do	100	24.4		[1] 14,000	+ .01	23.5	2.00	[1] 1.40	.60
													23.5	2.00	1.50	.50
24	Tinicum Island, Pennsylvania side.	25	11.45	do	18	W	do	60	24.4		43,500	[2] + .001	23.5	2.00	1.60	.40

[1] From bottom.

[2] Highest dilution planted.

TABLE Q.—*Delaware River above Reedy Island*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.			Dissolved oxygen, parts per million.		
											Number colonies per c. c. agar 37° 48 hours.	B. coli.	Per cent saturation.	At once.	24 hours at 20°.	Loss.
		1915.			*Feet.*				° *C.*			*C. c.*				
25	Marcus Hook, New Jersey side...	25	12.45 p. m.	Flood.	16	W.....	Fair/....	125	24.4	.....	16,000	+ .1	46.0	3.90	3.50	.40
26	Marcus Hook, mid-channel.....	25	12.50	...do..	34	W.....	...do.....	100	24.4	.....	[1] 11,800	+ .1	43.6	3.70	[1] 3.20	.50
													41.3	3.50	2.80	.70
27	Marcus Hook, Pennsylvania side.	25	12.55	...do..	15	W.....	...do.....	100	24.4	.....	700	+ .01	37.7	3.20	2.70	.50
28	Gordon Heights, Delaware side...	25	1.30	...do..	23	W.....	...do.....	125	24.4	.....	1,700	+ .1	48.4	4.10	4.10	.0
29	Gordon Heights, mid-channel....	25	1.35	...do..	35	W.....	...do.....	125	24.4	.....	[1] 9,800	+ .1	48.4	4.10	[1] 4.10	.0
													46.0	3.90	4.30	+.40
30	Gordon Heights, New Jersey side.	25	1.40	F. last.	14	W.....	...do.....	125	24.4	.....	9,900	+ .1	53.1	4.50	3.70	.80
31	Pigeon Point, New Jersey side...	25	2.10	E. beg.	52	W.....	...do.....	100	24.4	.....	15,000	+ .1	60.4	5.10	4.50	.60
32	Pigeon Point, mid-channel.....	25	2.15	...do..	35	W.....	...do.....	100	24.4	.....	[1] 5,800	− .1	57.8	4.90	[1] 4.60	.30
													56.6	4.80	4.10	.70
33	Pigeon Point, Delaware side.....	25	2.20	...do..	15	W.....	...do.....	100	24.4	.....	13,800	[2]+ .001	46.0	3.90	3.70	.20
34	Reedy Island, New Jersey side...	25	3.30	Ebb...	14	W.....	...do.....	150	24.4	.....	24,000	+ .1	77.9	6.60	6.00	.60
35	Reedy Island, mid-channel.....	25	3.35	...do..	33	W.....	...do.....	150	24.4	.....	[1] 4,300	+ .1	70.8	6.00	[1] 5.30	.70
													72.1	6.10	5.40	.70
36	Reedy Island, Delaware side.....	25	3.40	...do..	20	W.....	...do.....	150	24.4	.....	2,000	− .1	69.8	5.90	4.80	1.10
37	Reedy Island, New Jersey side...	27	11.10 a. m.	Flood.	14	NE...	Cloudy..	150	23.3	.....	270	+ .1	76.4	6.60	6.10	.50
38	Reedy Island, mid-channel.....	27	11.15	...do..	33	NE...	...do.....	125	23.3	.....	[1] 720	+ .1	68.3	5.90	[1] 5.20	.70
													75.3	6.50	5.70	.80
		1915														
39	Reedy Island, Delaware side.....	Aug. 27	11.20 a. m.	Flood.	20	NE...	Cloudy..	150	23.3	.....	210	+0.1	73.0	6.30	6.50	+0.20
40	Pigeon Point, Delaware side.....	27	11.20	...do..	11	NE...	...do.....	125	23.3	.....	1,800	+ .1	56.5	4.90	4.70	.20
41	Pigeon Point, mid-channel.....	27	12.25 p. m.	...do..	31	NE...	...do.....	125	23.3	.....	[1] 5,400	− .1	57.9	[1] 5.00	5.10	+ .10
													59.0	5.10	4.40	.70
42	Pigeon Point, New Jersey side.....	27	12.30	...do..	48	NE...	.....	125	23.3	.....	2,400	+ .1	57.9	5.00	5.10	+ .10
43	Gordon Heights, New Jersey side.	27	1.00	...do..	11	NE...	...do.....	125	23.3	.....	2,500	+ .1	53.3	4.60	4.20	.40
44	Gordon Heights, mid-channel....	27	1.10	...do..	32	NE...	...do.....	125	23.3	.....	[1] 5,600	+ .1	47.5	[1] 4.10	4.20	+ .10
													48.6	4.20	4.10	.10
45	Gordon Heights, Delaware side...	27	1.15	...do..	20	NE...	...do.....	100	23.3	.....	1,200	+ .1	49.8	4.30	4.10	.20
46	Marcus Hook, Pennsylvania side.	27	1.45	...do..	12	NE...	...do.....	40	23.3	.....	2,000	+ .1	32.4	2.80	2.60	.20
47	Marcus Hook, mid-channel.....	27	1.50	...do..	33	NE...	...do.....	40	23.3	.....	[1] 1,800	+ .01	41.7	[1] 3.60	3.70	+ .10
													44.0	3.80	3.80	.00
48	Marcus Hook, New Jersey side....	27	1.55	...do..	15	NE...	...do.....	40	23.3	.....	1,600	+ .1	49.8	4.30	4.40	+ .10
49	Tinicum Island, Pennsylvania side	27	1.30	...do..	19	NE...	...do.....	30	23.3	.....	5,800	+ .01	24.3	2.10	2.10	.00
50	Tinicum Island, mid-channel.....	27	1.35	...do..	34	NE...	...do.....	40	23.3	.....	[1] 3,400	+ .01	33.6	[1] 2.90	2.10	.80
													34.7	3.00	2.80	.20

51	Tinicum Island, New Jersey side..	27	1.40	...do..	21	NE...	...do.....	30	23.3	.....	2,100	+ .01	39.3	3.40	3.30	.10
52	Mifflin Bar, Pennsylvania side....	27	3.10	...do..	31	NE...	...do.....	30	23.3	.....	7,300	[2]+ .001	31.2	2.70	2.50	.20
53	Mifflin Bar, mid-channal.....	27	3.15	...do..	36	NE...	...do.....	30	23.3	.....	[1] 5,500	[2]+ .001	28.9	[1] 2.50	2.40	.10
													30.1	2.60	2.30	.30
54	Mifflin Bar, New Jersey side.....	27	3.20	...do..	24	NE...	...do.....	30	23.3	.....	4,000	+ .1	34.7	3.00	3.20	+ .20
55	League Island, Pennsylvania side	27	3.40	...do..	35	NE...	...do.....	25	23.3	.....	9,400	+ .01	31.2	2.70	2.50	.20
56	League Island, mid-channel.....	27	3.45	...do..	39	NE...	...do.....	25	23.3	.....	[1] 6,000	[2]+ .001	37.0	[1] 3.20	2.80	.40
													37.0	3.20	3.10	.10
57	League Island, New Jersey side...	27	3.50	...do..	23	NE...	...do.....	25	23.3	.....	2,800	+ .01	44.0	3.80	3.40	.40
58	Torresdale, Pennsylvania side....	28	11.25 a.m.	Ebb..	12	NE...	...do.....	25	20.5	.....	200	+ .1	74.8	6.80	5.60	1.20
59	Torresdale, mid-channel.....	28	11.30	...do..	30	NE...	...do.....	25	20.5	.....	[1] 200	+ .1	77.0	[1] 7.00	6.60	.40
													75.8	6.90	7.00	+ .10
60	Torresdale, New Jersey side.....	28	11.35	...do	16	NE...	...do.....	25	20.5	.....	600	+ .1	74.8	6.80	6.80	.00
61	Bridesburg, Pennsylvania side...	28	12.00 m.	E. last	10	NE...	...do.....	50	20.5	.....	1,200	+ .01	71.5	6.50	6.50	.00
62	Bridesburg, mid-channel.....	28	12.05 p.m.	...do..	28	NE...	...do.....	50	20.5	.....	[1] 400	+ .1	72.6	[1] 6.60	6.50	.10
													75.8	6.90	6.80	.10
63	Bridesburg, New Jersey side.....	28	12.10	...do..	26	NE...	...do.....	50	20.5	.....	300	− .1	73.6	6.70	6.60	.10
64	Coopers Point, New Jersey side...	28	12.40	F.beg.	14	NE...	Rain....	60	21.1	.....	4,000	+ .001	49.0	4.40	3.00	1.40
65	Coopers Point, mid-channel.....	28	12.45	...do..	30	NE...	...do.....	60	21.1	.....	[1] 5,000	+ .001	66.8	[1] 6.00	5.90	.10
													66.8	6.00	5.70	.30
66	Coopers Point, Pennsylvania side.	28	12.50	...do..	45	NE...	...do.....	60	21.1	.....	12,000	+ .001	45.7	4.10	3.40	.70
67	Kaighn Point, New Jersey side...	28	1.10	...do..	29	NE...	...do.....	75	21.6	.....	3,000	+ .01	53.9	4.80	4.60	.20
68	Kaighn Point, mid-channel.....	28	1.15	...do..	28	NE...	...do.....	75	21.6	.....	[1] 12,000	− .01	47.2	[1] 4.20	3.10	1.10
													44.9	4.00	3.40	.60
69	Kaighn Point, Pennsylvania side.	28	1.25	Flood.	34	NE...	...do.....	75	21.6	.....	10,000	[2]+ .0001	29.2	2.60	2.00	.60
70	Gloucester Point, Pennsylvania side.....	28	4.30	...do..	38	NE...	...do.....	50	21.6	.....	5,000	+ .01	39.3	3.50	2.90	.60
71	Gloucester Point, mid-channel....	28	4.35	...do..	32	NE...	...do.....	50	21.6	.....	[1] 2,000	− .01	47.2	[1] 4.20	3.80	.40
													44.9	4.00	3.80	.20
72	Gloucester Point, New Jersey side	28	4.40	...do..	33	NE...	...do.....	50	21.6	.....	5,000	+ .01	49.4	4.40	4.10	.30
73	Torresdale, Pennsylvania side....	30	2.55	...do..	11	NE...	Cloudy..	.....	20.0	.....	1,340	+ .1	76.3	7.00	6.65	.35
74	Torresdale, mid-channel.....	30	3.00	...do..	15	NE...	...do.....	.....	20.0	.....	[1] 820	+ .1	81.7	[1] 7.50	7.30	.20
													82.3	7.55	7.15	.40
75	Torresdale, New Jersey side.....	30	3.10	...do..	15	NE...	...do.....	.....	20.0	.....	2,440	+1	69.2	6.35	6.60	+ .25
		1915														
76	Bridesburg, Pennsylvania side..	Aug. 30	3.45 p.m.	Flood.	33	NE...	...do.....	.....	20.5	.....	40,000	[2]+ .001	60.0	5.45	4.35	1.10
													73.2	6.65	[1] 6.35	.30
77	Bridesburg, mid-channel.....	30	3.50	...do..	15	NE...	...do.....	.....	20.5	.....	[1] 7,600	+ .1	70.4	6.40	6.45	+ .50
78	Bridesburg, New Jersey side.....	30	3.55	...do..	20	NE...	...do.....	.....	20.5	.....	3,600	+ .01	74.3	6.85	6.65	.20
79	Coopers Point, New Jersey side..	30	4.20	...do..	15	NE...	...do.....	.....	21.1	.....	17,000	− .01	46.2	4.15	3.70	.45
80	Coopers Point, mid-channel.....	30	4.30	...do..	30	NE...	...do.....	.....	21.1	.....	[1] 23,000	+ .01	48.4	4.35	[1] 3.65	.70
													44.5	4.00	3.65	.35
81	Coopers Point, Pennsylvania side.	30	4.35	...do..	46	NE...	...do.....	.....	21.1	.....	33,000	+ .001	36.2	3.25	2.45	.80
82	Kaighn Point, New Jersey side..	30	4.50	...do..	31	NE...	...do.....	.....	21.6	.....	16,000	− .01	44.9	4.00	3.60	.40
83	Kaighn Point, mid-channel.....	30	5.00	...do..	36	NE...	...do.....	.....	21.6	.....	[1] 4,000	− .01	42.7	3.80	[1] 3.55	.25
84	Kaighn Point, Pennsylvania side.	30	5.05	...do..	36	NE...	...do.....	.....	21.6	.....	8,000	+ .01	34.3	3.05	2.95	.10
85	Gloucester Point, New Jersey side.	30	5.30	...do..	17	NE...	...do.....	.....	21.6	.....	3,000	− .01	43.3	3.85	3.40	.45
86	Gloucester Point, mid-channel...	30	5.35	...do..	43	NE...	...do.....	.....	21.6	.....	[1] 6,000	+ .01	36.5	3.25	[1] 2.80	.45
													35 9	3.20	2.35	.85

[1] From bottom.

[2] Highest dilution planted.

TABLE Q.—*Delaware River above Reedy Island*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity. m	Temperature. m	Salinometer reading.	Bacteria in water.			Dissolved oxygen, parts per million.		
											Number colonies per c. c. agar 37° 48 hours.	B. coli.	Per cent saturation.	At once.	24 hours at 20°.	Loss.
		1913.			*Feet.*				°*C.*			*C. c.*				
87	Gloucester Point, Pennsylvania side.	Aug. 30	5.40 p. m.	Flood..	20	NE....	Cloudy..	.....	21.6	.....	34,000	+ .01	35.9	3.20	2.40	.80
88	League Island, New Jersey side..	31	2.15	...do..	18	N.....	Fair....	60	21.1	.....	1,200	+ .01	44.5	4.00	3.70	.30
89	League Island, mid-channel.....	31	2.20	...do..	34	N.....	...do....	60	21.1	.....	[1] 2,000	+ .01	44.5	4.00	[1] 3.45	.55
90	League Island, Pennsylvania side.	31	2.25	...do..	29	N.....	...do....	60	21.1	.....	12,700	[2]+ .001	44.5	4.00	3.35	.65
91	Mifflin Bar, New Jersey side.....	31	2.55	...do..	19	N.....	...do....	60	21.1	.....	1,600	[2]+ .001	34.5	3.10	2.90	.20
92	Mifflin Bar, mid-channel.....	31	3.00	...do..	30	N.....	...do....	60	21.1	.....	[1] 3,600	+ .01	43.4	3.90	2.90	1.00
93	Mifflin Bar, Pennsylvania side...	31	3.05	...do..	26	N.....	...do....	30	21.1	.....	14,600	[2]+ .001	38.4	3.45	[1] 2.65	.80
94	Tinicum Island, New Jersey side.	31	3.45	...do..	18	N.....	...do....	25	21.1	.....	700	+ .01	36.2	3.25	3.05	.20
95	Tinicum Island, mid-channel....	31	3.50	...do..	34	N.....	...do....	50	21.1	.....	[1] 800	+ .1	37.9	3.40	2.95	.45
96	Tinicum Island, Pennsylvania side.	31	4.00	...do..	13	N.....	...do....	50	21.1	.....	3,300	+ .1	49.0	4.40	4.75	+ .35
97	Marcus Hook, New Jersey side...	31	5.05	...do..	16	N.....	...do....	20	21.1	.....	500	+ .1	42.9	3.85	[1] 3.30	.55
98	Marcus Hook, mid-channel.....	31	5.10	...do..	34	N.....	...do....	20	21.1	.....	[1] 300	+ .1	44.0	3.95	4.00	+ .50
99	Marcus Hook, Pennsylvania side.	31	5.15	...do..	13	N.....	...do....	20	21.1	.....	400	− .1	41.8	3.75	3.15	.60
100	Gordon Heights, Delaware side..	31	6.10	...do..	29	N.....	...do....	60	21.1	.....	600	+ .1	47.3	4.25	[1] 4.05	.20
101	Gordon Heights, mid-channel....	31	6.15	...do..	36	N.....	...do....	50	21.1	.....	.....	.....	47.9	4.30	4.00	.30
102	Gordon Heights, New Jersey side.	31	6.25	F.last	52	N.....	...do....	50	21.1	.....	.....	.....	50.1	4.50	4.40	.10
103	Pigeon Point, New Jersey side...	31	6.55	E.beg	19	N.....	...do....	40	21.1	.....	.....	.....	57.4	5.15	4.70	.45
104	Pigeon Point, mid-channel.....	31	7.00	...do..	36	N.....	...do....	30	21.1	.....	.....	.....	59.6	5.35	[1] 5.20	.15
105	Pigeon Point, Delaware side.....	31	7.05	...do..	13	N.....	...do....	40	21.1	.....	.....	.....	58.5	5.25	4.20	1.05
106	Reedy Island, New Jersey side...	Sept. 1	8.30 a. m.	Ebb..	16	NE....	...do....	60	20.0	.....	100	+ .1	62.4	5.60	5.25	.35
107	Reedy Island, mid-channel.....	1	8.35	...do..	36	NE....	...do....	60	20.0	.....	[1] 400	− .1	65.7	5.90	5.60	.30
108	Reedy Island, Delaware side.....	1	8.40	...do..	22	NE....	...do....	60	20.0	.....	200	− .1	67.4	6.05	[1] 5.90	.15
109	Opposite Pigeon Point channel...	Oct. 13	2.00 p. m.	Flood.	33	S.....	Cloudy..	75	16.6	1.0050	1,500	− .1	68.0	6.10	5.45	.65
110	Opposite New Castle channel....	13	2.30	...do..	33	S.....	...do....	75	16.1	1.0060	1,800	+ .1	60.7	5.45	5.35	.10
111	Opposite Delaware City channel, New Jersey side.	13	3.00	...do..	34	S.....	...do....	75	16.1	1.0060	1,200	− .1	76.3	7.00	7.20	+ .20
													74.1	6.80	[1] 7.00	+ .20
													74.1	6.80	6.90	+ .10
													74.7	6.85	7.05	+ .20
													.....	.....	.....	.....
													.....	.....	.....	.....
													.....	.....	.....	.....

112	Opposite Reedy Island channel, New Jersey side	13	3.30	...do..	35	S. brisk	...do....	30	16.1	1.0060	170	+1							
113	Opposite Pigeon Point channel...	15	3.30	...do...	33	None..	Fair	100	17.2	.....	75	+1							
114	Opposite New Castle channel.....	15	3.05	...do..	33	...do..	...do....	60	17.2	.....	25	+1							
115	Opposite Delaware City channel, New Jersey side.	15	2.45 p.m.	Flood.	34	None .	...do.....	30	17.2	.....	Spr.	+ .1							
116	Opposite Reedy Island channel, New Jersey side.	15	2.20	...do..	35	...do..	...do.....	40	17.2	.....	Spr.	+1							
117	Pigeon Point, Delaware side.....	16	9.30 a.m.	Ebb ..	13	E.....	Cloudy..	100	16.3	1.0015	2,500	− .1							
118	....do.....	16	9.30	...do..	13	E.....	...do.....	100	16.3	1.0015	[1] 2,000	+ .1							
118a	Pigeon Point channel.....	16	9.35	...do..	33	E.....	...do.....	100	16.3	1.0015	[1] 5,000	+ .1							
118b	Pigeon Point, channel side.....	16	9.35	...do..	33	E.....	...do.....	100	16.3	1.0015	2,000	+ .1							
119	Pigeon Point, New Jersey side...	16	9.40	...do..	50	E.....	...do.....	100	16.3	1.0015	59,000	+ .1							
120	Above mouth of Christiana Creek.	16	10.00	...do..	33	E.....	...do.....	100	16.3	1.0015	7,500	+ .1							
121	Gordon Heights, Pennsylvania side.	16	10.16	...do..	26	E.....	...do.....	100	16.3	1.0005	3,500	+ .1							
122a	Gordon Heights channel.....	16	10.30	...do..	33	E.....	...do.....	100	16.6	1.0005	[1] 2,500	+ .1							
122b	....do.....	16	10.30	...do..	33	E.....	...do.....	100	16.6	1.0005	6,000	+ .01							
123	Gordon Heights, New Jersey side.	16	10.30	...do..	27	E.....	...do.....	100	16.6	1.0005	4,500	+ .1							
124	Marcus Hook, Pennsylvania side.	16	11.00	...do..	13	E.....	...do.....	30	17.2	.9995	1,000	+ .1							
125	Marcus Hook channel.....	16	11.00	...do..	34	E.....	...do.....	30	17.2	1.0000	[1] 2,000	+ .01							
125b	....do.....	16	11.00	...do..	34	E.....	...do.....	30	17.2	1.0000	2,000	− .1							
126	Marcus Hook, New Jersey side...	16	11.00	...do..	16	E.....	...do.....	30	17.2	1.0000	2,500	+ .1							
127	Tinicum Island, Pennsylvania side.	16	12.00 m.	...do..	15	E.....	...do.....	25	16.9	.9995	2,500	+ .1							
128	Tinicum Island channel.....	16	12.02 p.m.	...do..	36	E.....	...do.....	25	16.9	.9995	[1] 5,000	+ .01							
128b	....do.....	16	12.02	...do..	36	E.....	...do.....	25	16.9	.9995	6,000	+ .1							
129	Tinicum Island, New Jersey side.	16	12.05	...do..	22	E.....	...do.....	25	16.9	.9995	8,000	+ .1							
130	Mifflin Bar, Pennsylvania side...	16	1.00	...do..	30	E.....	...do.....	40	16.9	.9990	63,500	+ .001							
131	Mifflin Bar channel.....	16	1.05	...do..	35	E.....	...do.....	40	16.9	.9990	[1] 4,500	− .01							
131b	....do.....	16	1.05	...do..	35	E.....	...do.....	40	16.9	.9990	5,500	+ .01							
132	Mifflin Bar, New Jersey side.....	16	1.00	...do..	23	E.....	...do.....	40	16.9	.9990	5,500	+ .01							
133	League Island, Pennsylvania side	16	1.30	...do..	34	E.....	...do.....	25	16.9	.9990	66,000	[2]+ .0001							
134	League Island channel.....	16	1.30	...do..	39	E.....	...do.....	25	16.9	.9990	[1] 53,000	+ .001							
134b	....do.....	16	1.30	...do..	39	E.....	...do.....	25	16.9	.9990	44,500	+ .001							
135	League Island, New Jersey side..	16	1.35	...do..	23	E.....	...do.....	40	16.9	.9990	26,500	+ .01							
136	Opposite Pigeon Point channel...	18	11.20 a.m.	...do..	33	S.....	...do.....	100	16.6	1.0000	1,750	+ .1							
137	Opposite New Castle channel....	18	11.40	...do..	33	S.....	...do.....	75	16.6	1.0005	700	+1							
138	Opposite Delaware City, channel, New Jersey side.	18	12.10 p.m.	...do..	32	S.....	...do.....	75	16.6	1.0020	295	+1							
139	Opposite Reedy Island channel, New Jersey side.	18	12.40	...do..	32	S.....	...do.....	30	16.6	1.0025	210	+1							
140	Opposite Pigeon Point channel..	22	7.00 a.m.	L. w..	36	None .	Fair.....	100	16.6	1.0000	500	+ .1							
141	Opposite New Castle channel.....	22	7.20	F. beg.	36	...do..	...do.....	100	16.6	1.0000	250	+10							
142	Opposite Delaware City channel, New Jersey side.	22	8.00	...do..	35	...do..	...do.....	40	17.2	1.0020	30	[2]+ .1							
143	Opposite Reedy Island channel, New Jersey side.	22	8.30	Flood.	35	...do..	...do.....	10	17.2	1.0035	73	+1							
144	....do.....	23	9.00	...do..	33	N.....	...do.....	.....	16.1	1.0020	12	−10							
145	Opposite Delaware City channel, New Jersey side.	23	9.30	...do..	34	N.....	...do.....	.....	16.1	1.0010	19	−10							

[1] From bottom.

[2] Highest dilution planted.

TABLE Q.—*Delaware River above Ready Island*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.			Dissolved oxygen, parts per million.		
											Number colonies per c. c. agar 37° 48 hours.	B. coli.	Per cent saturation.	At once.	24 hours at 20°.	Loss.
		1915.			*Feet.*				° *C.*			*C. c.*				
146	Opposite New Castle channel	23	10.00	Flood.	34	N	Fair		16.1	1.0000	48	−10				
147	Opposite Pigeon Point channel	23	10.30	do	34	N	do		16.1	1.0000	45	−10				
148	Opposite New Castle channel	26	8.30	do	33	SW	Cloudy	100	15.5	1.0000	6,000	[2]+ .1				
149	Opposite Delaware City channel, New Jersey side.	26	9.10	do	33	SW	do	75	14.4	1.0015	3,930	+1				
150	Opposite Reedy Island channel, New Jersey side.	26	9.45	do	34	SW	do	10	14.7	1.0025	720	+1				
151	Opposite Pigeon Point channel	Nov. 8	1.15 p. m.	do	33		Fair	100			3,290	+ .1				
152	Opposite New Castle channel	8	1.45	do	33		do	100			2,510	+ 1				
153	Opposite Delaware City channel	8	2.15	F. last.	34		do	75			Spr.	+ 1				
154	Opposite Reedy Island, New Jersey side.	8	2.45	E. beg.	34		do	20			86	+10				
155	Junction of channels below Bordentown.	Dec. 4	8.30 a. m.	L. w.	16	None	do	15	2.7		200	[2]+ .1				
156	Opposite Roebling	4	8.45	do	14	do	do	20	2.7		115	[2]+ .1				
157	Opposite Florence	4	9.10	F. beg.	21	do	do	20	2.7		53	[2]+ .1				
158	Opposite Bristol	4	9.30	Flood.	22	do	do	15	2.7		73	+ 1				
159	Opposite Beverly	4	10.00	do	31	NW	do	15	2.7		67	[2]+ .1				
160	Opposite Andalusia	4	10.20	do	14	NW	do	10	3.7		145	[2]+ .1				
161	Torresdale, Pennsylvania side	4	10.35	do	13	NW	Cloudy	10	2.7		212	+ .1				
162	Torresdale channel	4	10.39	do	32	NW	do	10	2.7		105	+ 1				
163	Torresdale, New Jersey side	4	10.42	do	18	NW	do	25	2.7		138	+ .1				
164	Bridesburg, Pennsylvania side	4	11.15	do	14	NW	do	25	2.7		325	+ .1				
165	Bridesburg channel	4	11.15	do	32	NW	do	25	2.7		520	[2]+ .01				
166	Bridesburg, New Jersey side	4	11.15	do	30	NW	do	25	2.7		390	+ .1				
167	Kaighn Point, New Jersey side	6	12.00 m.	do	33	NW	do	35	5.5		240	+ .1				
168	Kaighn Point channel	6	12.00	do	32	NW	do	35	5.5		265	+ .1				
169	Kaighn Point mid-channel	6	12.00	do	32	NW	do	35	5.5		[1] 285	+ .01				
170	Kaighn Point, Pennsylvania side	6	12.00	do	38	NW	do	30	5.5		385	+ .01				
171	Gloucester, New Jersey side	6	12.30 p. m.	do	18	NW	do	50	5.5		150	+ .01				
172	Gloucester channel	6	12.30	do	44	NW	do	50	5.5		275	+ .01				
173	do	6	12.30	do	44	NW	do	50	5.5		[1] 165	+ .01				
174	Gloucester, Pennsylvania side	6	12.30	do	21	NW	do	50	5.5		185	+ .01				
175	League Island, New Jersey side	6	1.00	do	23	NW	do	35	5.5		240	− .1				
176	League Island channel	6	1.00	do	39	NW	do	30	5.5		315	+ .1				

177	.....do.....			6	1.00	...do..	39	NW....	...do....	30	5.5	.....	[1] 245	+ .1	.....	.....	.....	.....
178	League Island, Pennsylvania side.			6	1.00	...do..	34	NW....	...do....	25	5.5	.....	255	+ .1	.....	.....	.....	.....
179	Mifflin Bar, New Jersey side.....			6	1.30	...do..	24	NW....	...do....	25	5.5	.....	100	+ .1	.....	.....	.....	.....
180	Mifflin Bar channel.....			6	1.30	...do..	36	NW....	...do....	25	5.5	.....	185	− .1	.....	.....	.....	.....
181	Mifflin Bar.....			6	1.30	...do..	36	NW....	...do....	25	5.5	.....	[1] 390	+ .1	.....	.....	.....	.....
182	Mifflin Bar, Pennsylvania side...			6	1.30	...do..	31	NW....	...do....	30	5.5	.....	330	+ .1	.....	.....	.....	.....
183	Tinicum Island, New Jersey side.			6	2.00	F. last.	21	NW....	...do....	25	5.5	.....	265	+ .1	.....	.....	.....	.....
184	Tinicum Island channel.....			6	2.00	...do..	38	NW....	...do....	25	5.5	.....	245	− .1	.....	.....	.....	.....
185	.....do.....			6	2.00	...do..	38	NW....	...do....	25	5.5	.....	[1] 215	− .1	.....	.....	.....	.....
186	Tinicum Island, Pennsylvania side			6	2.00	...do..	20	NW....	...do....	25	5.5	.....	165	− .1	.....	.....	.....	.....
187	Marcus Hook, New Jersey side...			6	2.45	E. beg.	18	NW....	...do....	35	5.5	.....	120	+ .1	.....	.....	.....	.....
188	Marcus Hook channel.....			6	2.45	...do..	36	NW....	...do....	35	5.5	.....	210	− .1	.....	.....	.....	.....
189	.....do.....			6	2.45	...do..	36	NW....	...do....	35	5.5	.....	[1] 115	+ .1	.....	.....	.....	.....
190	Marcus Hook, Pennsylvania side.			6	2.45	...do..	15	NW....	...do....	40	5.5	.....	95	+ .1	.....	.....	.....	.....
191	Gordon Heights, Delaware side..			6	3.20	Ebb ..	28	NW....	...do....	50	5.5	.....	130	+ .1	.....	.....	.....	.....
192	Gordon Heights (Del.) channel...			6	3.20	...do..	35	NW....	...do....	75	5.5	.....	100	− .1	.....	.....	.....	.....
193	.....do.....			6	3.20	...do..	35	NW....	...do....	75	5.5	.....	[1] 110	+ .1	.....	.....	.....	.....
194	Gordon Heights, New Jersey side.			6	3.20	...do..	24	NW....	...do....	100	5.5	.....	245	+ .1	.....	.....	.....	.....
195	Pigeon Point, New Jersey side...			6	3.50	...do..	51	NW....	...do....	100	5.5	.....	180	− .1	.....	.....	.....	.....
196	Pigeon Point channel.....			6	3.50	...do..	34	NW....	...do....	60	5.5	.....	[1] 135	− .1	.....	.....	.....	.....
197	.....do.....			6	3.50	...do..	34	NW....	...do....	60	5.5	.....	135	+ .1	.....	.....	.....	.....
198	Pigeon Point, Delaware side.....			6	3.50	...do..	14	NW....	...do....	75	5.5	.....	260	+ .1	.....	.....	.....	.....
199	Pigeon Point mid-channel.....			8	9.30 a. m.	Flood.	33	NW....	...do....	100	3.8	.....	88	+ .1	.....	.....	.....	.....
200	Opposite New Castle.....			8	10.00	...do..	33	NW....	...do....	100	3.8	.....	33	+ 1	.....	.....	.....	.....
201	Opposite Delaware City, channel.			8	11.30	...do..	34	NW....	...do....	100	3.8	.....	35	+ 1	.....	.....	.....	.....
202	Reedy Island, Delaware side.....			8	11.45	...do..	32	NW....	...do....	100	3.8	.....	48	+ 1	.....	.....	.....	.....
203	Reedy Island channel.....			8	11.45	...do..	34	NW....	...do....	75	3.8	.....	33	[2] + .1	.....	.....	.....	.....
204	.....do.....			8	11.50	...do..	34	NW....	...do....	75	3.8	.....	[1] 38	+ 1	.....	.....	.....	.....
205	Reedy Island, New Jersey side...			8	11.50	...do..	13	NW....	...do....	75	3.8	.....	33	+ 1	.....	.....	.....	.....
206	Christiana River, bridge.....	Oct.	13	11.00	...do..	.....	W.....	Fair.....	25	15.0	.....	300	+ .01	.....	.....	.....	.....
207	Christiana River, Delaware pulp mills.		13	11.20	...do..	.....	W.....	...do....	40	15.8	.....	4,000	− .01	.....	.....	.....	.....
208	Christiana River, Harlan & Hollingsworth pulp mills.		13	11.35	...do..	.....	W.....	...do....	100	15.5	.....	10,000	− .01	.....	.....	.....	.....
209	Christiana River, below Third Street Bridge.		13	1.20 p. m.	...do..	.....	W.....	...do....	100	15.5	.....	3,000	+ .001	.....	.....	.....	.....
210	Christiana River, mouth of Brandywine Creek.		13	1.28	...do..	24	W.....	...do....	60	15.5	.....	1,600	+ .01	.....	.....	.....	.....
211	Christiana River, at mouth.....		13	1.40	...do..	23	W.....	...do....	50	15.5	.....	2,000	+ .1	.....	.....	.....	.....

[1] From bottom.

[2] Highest dilution planted.

TABLE R.

Delaware River and Delaware Bay below Reedy Island.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water samples.	
											Number colonies per c. c., agar 37° 48 hours.	B. coli.
		1915.			*Feet.*				°*C.*			*c. c.*
1	Opposite lower end Stony Point Shoal channel, Delaware side.	Oct. 13	4.00 p. m.	Flood...	30	S.....	Cloudy..	15	16.1	1.0065	88	+ 1
2	Opposite Liston Point channel	13	4.30	...do.....	30	S.....	...do.....	5	15.9	1.0100	54	−10
3	Opposite Arnold Shoal light buoy channel	13	5.00	...do.....	30	S.....	...do	0	15.9	1.0100	38	+10
4	Opposite Ship John Light, New Jersey side	13	5.30	...do.....	16	S.....	...do.....	0	15.9	1.0115	28	−10
5	.....do	15	12.45	...do.....	19	None....	Foggy...	5	16.6	1.0110	.....	+10
6	Opposite Arnold Shoal light buoy channel	15	1.15	...do.....	30	...do....	...do.....	5	17.2	1.0000	.....	+ 1
7	Opposite Liston Point, channel	15	1.45	...do.....	30	...do.....	...do.....	0	18.3	1.0030	.....	+10
8	Opposite lower end Stony Point Shoal channel, Delaware side.	15	2.00	...do.....	30	...do.....	Fair.....	5	18.7	1.0010	.....	+ 1
9	.....do	18	1.10	Ebb....	30	S.....	Cloudy..	20	16.6	1.0035	55	[1]+ .1
10	Opposite Liston Point channel	18	1.40	E. last..	30	S.....	...do.....	5	16.6	1.0055	120	[1]+ .1
11	Opposite Arnold Shoal light buoy channel	18	2.00	F. beg ..	30	S.....	...do.....	5	16.6	1.0055	95	+10
12	Opposite Ship John light, New Jersey side	18	2.30	...do.....	19	S.....	...do.....	0	16.6	1.0100	75	+10
13	Opposite lower end Stony Point Shoal channel, Delaware side.	22	9.00 a. m.	Flood...	30	None....	Fair.....	5	17.2	1.0050	44	+10
14	Opposite Liston Point channel	22	9.30	...do.....	30	...do.....	...do.....	5	16.9	1.0080	32	+10
15	Opposite Arnold Shoal light buoy channel	22	10.00	...do.....	30	...do.....	...do.....	5	16.9	1.0105	27	+10
16	Opposite Ship John Light, New Jersey side	22	10.45	...do.....	16	...do.....	...do.....	5	16.9	1.0115	20	+10
17	.....do	23	7.00	...do.....	18	N.....	...do.....	5	15.5	1.0100	20	−10
18	Opposite Liston Point channel	23	8.00	...do.....	30	N.....	...do.....	5	15.9	1.0060	10	−10
19	Opposite lower end Stony Point Shoal channel, Delaware side.	23	8.30	...do.....	30	N.....	...do.....	5	16.1	1.0030	44	−10
20	.....do	26	10.15	...do.....	30	S. W....	Cloudy..	5	15.0	1.0050	64	+10
21	Opposite Arnold Shoal Light buoy channel	26	11.30	...do.....	30	S. W....	...do.....	5	15.3	1.0110	32	−10
22	Opposite Ship John Light channel, Delaware side	26	12.15 p. m.	F. last ..	17	S. W....	Fair.....	0	15.5	1.0140	29	+10
23	Ben Davis Point bell buoys channel	26	12.45	E. beg ..	54	S. W....	...do.....	0	15.5	1.0150	23	−10
24	Opposite Cross Ledge Light, New Jersey side	26	1.15	Ebb.....	16	S. W....	...do	0	16.1	1.0160	12	−10
25	Opposite Miah Maull Light, New Jersey side	26	1.45	...do.....	19	S. W....	...do	0	16.4	1.0180	8	−10
26	Opposite Egg Island light house, New Jersey side	26	2.00	...do.....	10	S.....	...do	0	16.1	1.0200	15	−10
27	Opposite lower end Stony Point Shoal	Nov. 8	3.15	...do.....	30	S.....	...do.....	0	.....	.....	Spr.	+ 1
28	Opposite Liston Point	8	3.45	...do.....	30	S.....	...do.....	0	.....	.....	Spr.	+ 1
29	At Arnold Shoal light buoy	8	4.15	...do.....	30	S.....	...do.....	0	.....	.....	45	−10
30	Opposite Ship John Light, New Jersey side	8	4.45	...do.....	17	S.....	...do.....	0	.....	.....	56	−10

31	Opposite lower end Stony Point shoal channel	Dec.	8	12.45	Flood	30	N. W.	Cloudy	5	5.0		34	+10
32	Opposite Liston Point channel		8	1.10	do	30	N. W.	do	5	5.0		34	−10
33	Opposite Arnold Shoal buoy channel		8	5.05	Ebb	30	S. W.	do	0	5.0		25	+ 1
34	Opposite Ship John Light, ½ mile to west		8	5.45	do	45	S. W.	do	0	5.0		25	−10
35	Midway between Ship John and Egg Island light		8	6.30	do	23	S. W.	do	0	5.0		36	−10
36	Opposite Egg Island Light		8	7.30	do	10	S. W.	do	0	5.0		28	−10
37	Off mouth Maurice River		16	1.30	do	8	None	Fair	35	.5		52	+10
38	Opposite Egg Island light		16	2.00	do	10	do	do	35	.5		23	−10
39	Between Egg Island and Ship John light		16	3.00	L. W.	23	do	do	35	.5		19	−10
40	Off Ship John Light, New Jersey side		16	4.00	Flood	16	do	do	37	.5		37	+10

Highest dilution planted.

TABLE S.—*Delaware Bay—Maurice River Cove.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli. in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
1	Section C, bed No. 136	Sept. 20	11.20 a. m.	Ebb..	12	SW...	Fair....	30.....	25.5	1.0140	1 25	+10	7,500	0
											136	−10		
2	Section C, bed No. 131	20	11.35	...do..	8	SW...	...do....	30.....	25.5	1.0140	1 30	−10	8,500	1
											28	−10		
3	Section C, bed No. 244	20	11.50	...do..	10	SW...	...do....	10.....	25.5	1.0140	1 15	−10	800	0
											13	−10		
4	Section C, bed No. 196	20	12.35 p. m.	...do..	12	SW...	...do....	60.....	25.5	1.0135	1 35	+ 1	600	1
											20	+10		
5	Section C, bed No. 54	20	12.50	E.Last	7	SW...	...do....	30.....	25.5	1.0140	1 45	+10	1,200	0
											32	−10		
6	Section C, bed No. 54	20	12.50	...do..	7	SW...	...do....	30.....	25.5	1.0140	.....	.....	6,500	2
7	Section C, bed No. 97	20	1.15	F.Beg.		SW...	...do....	10.....	25.5	1.0140	1 70	−10	8,500	1
											15	+10		
8	Section C, bed No. 306	22	11.30 a. m.	Ebb..	15	NW...	...do....	5.....	20.5	1.0150	1 10	+ 1	50	0
											37	−10		
9	Section C, bed No. 611	22	12.00 m.	...do..	20	NW...	...do....	5.....	21.1	1.0165	1 25	+10	150	0
											9	−10		
10	Section C, bed No. 605	22	12.40 p. m.	...do..	20	NW...	...do....	5.....	21.1	1.0160	1 45	+10	50	1
											8	−10		
11	Section C, bed No. 439	22	1.40	...do..	12	NW...	...do....	5.....	21.6	1.0165	1 44	+ 1	50	0
											4	−10		
12	Section C, bed No. 394	22	2.50	...do..	10	NW...	...do....	30.....	21.1	1.0150	1 25	−10	100	0
											17	−10		
13	Section C, bed No. 367	22	3.10	...do..	8	NW...	...do....	30.....	21.6	1.0150	1 38	−10	0	0
											17	−10		
14	Section B, bed No. 154	29	11.15	Flood.	15	NW...	...do....	Slight.....	16.3	1.0155	1 7	−10	20	0
											14	+10		
15	Section A, bed No. 214	29	11.35	...do..	12	NW...	...do....	.....do.....	16.6	1.0150	1 7	−10	0	0
											11	−10		
16	Section A, near bed No. 249	29	11.50	...do..	12	NW...	...do....	.....do.....	16.6	1.0150	1 27	−10	5	0
											26	−10		
17	Section A, near bed No. 31	29	12.05	...do..	12	NW...	...do....	.....do.....	16.6	1.0150	1 17	−10	30	1
											16	−10		
18	Section A, near bed No. 109	29	12.25	...do..	12	NW...	...do....	.....do.....	16.6	1.0150	1 17	−10	0	0
											8	−10		

19	Section A, near bed No. 158		29	12.45	F. Last	12	NW.	do	do	16.6	1.0150	[1] 20 8	−10 −10	5	0
20	Section A, George Robbins's bed		29	1.15	H. W.	12	NW.	do	do	16.6	1.0160	[1] 6 9	−10 −10	20	0
21	Section B, Stites's bed		29	1.45	E. Beg.	20	NW.	do	do	17.2	1.0170	[1] 8 8	−10 −10	5	0
22	Section B, near bed No. 192		29	2.10	Ebb	15	NW.	do	do	16.3	1.0155	[1] 9 8	−10 −10	20	0
23	Section B, bed No. 106		29	2.35	do	15	NW.	do	do	17.2	1.0155	[1] 7 4	−10 −10	50	3
24	Section B, bed No. 58		29	2 55	do	12	NW.	do	do	17.2	1.0155	[1] 20 12	−10 −10	40	1
25	Section B, bed No. 20		29	3.15	do	12	N.	do	do	17.2	1.0150	[1] 29 28	−10 + 1	175	1
26	Section D, bed No. 37	Oct.	1	9.45 a. m.	do	8	E.	Stormy	Moderate	16.9	1.0160	[1] 18 35	+ 1 −10	300	23
27	Section D, bed No. 41		1	10.00	do	15	E.	do	do	17.2	1.0160	[1] 45 38	−10 +10	400	14
28	Section D, bed No. 406		4	4.05 p. m.	Flood	15	SW.	Fair	0	18.3	1.0155	[1] 29 22	−10 −10	810	4
29	Section D, bed No. 442		4	4.25	do	15	SW.	do	0	18.3	1.0180	[1] 30 41	−10 +10	450	0
30	Section D, bed No. 297		4	4.35	do	15	SW.	do	0	18.3	1.0180	[1] 91 16	−10 +10	1,640	5
31	Section D, bed No. 332		4	4.55	do	15	SW.	do	0	18.3	1.0175	[1] 92 17	−10 −10	2,070	5

[1] From bottom.

TABLE T.—*Delaware Bay—Delaware Side.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Water over beds.		Shellfish.	
											Number of colonies per c. c., agar 37°, 48 hours.	B. coli.	Number of colonies per c. c., agar 37°, 48 hours.	Score based on B. coli. in shell liquor.
		1915.			*Feet.*				°*C.*			*C. c.*		
1	Oscar Cannon's bed	Oct. 6	1.10 p. m.	Ebb...	10	NE....	Cloudy..	Moderate....	17.2	1.0170	[1] 310	+10	200	1
											160	+ 1		
2	Peter Paynter's bed	6	1.30	...do...	10	NE....	...do....	.....do.....	17.2	1.0170	[1] 100	+10	100	2
											60	+10		
3	John C. Peterson's bed	6	1.50	Flood.	14	NE....	...do....	Slight.....	17.2	1.0165	[1] 30	−10	100	2
											50	−10		
4	Near E. Johnson's bed	6	2.30	...do...	14	NE....	...do....	.....do.....	17.2	1.0160	[1] 0	−10	200	2
											30	−10		
5	Wm. Shillingsburg's bed	6	2.40	...do...	14	NE....	...do....	.....do.....	17.2	1.0160	[1] 90	−10	100	5
											70	−10		
6	Winsmore & Walls' bed	6	3.10	...do...	16	NE....	...do....	.....do.....	17.2	1.0160	[1] 290	−10	200	0
											30	−10		
7	Geo. H. Woodall's bed, taken from schooner.	6	3.45	Ebb...	.....	.....	.....	.....	.....	.....	.....	.....	300	1
								Slight.....	17.2	1.0160	[1] 50	−10		
								.....do.....	17.2	1.0160	110	−10		
8	John Arnold's bed	6	4.15	Flood.	16	NE....	Cloudy..	.....do.....	17.2	1.0150	[1] 30	−10	100	1
											30	−10		
9	J. Peterson's bed	7	11.05 a. m.	Ebb...	20	NE....	Rain....	0.....	17.7	1.0175	[1] 5	−10	200	1
											17	−10		
10	Wm. Shillingsburg's bed	7	11.40	...do...	18	NE....	...do....	0.....	17.7	1.0170	[1] 11	+10	100	1
											17	−10		
11	Winsmore & Walls' bed, southwest corner.	7	12.00 m.	...do...	16	NE....	...do....	0.....	17.7	1.0170	[1] 39	−10	200	1
											Spr.	−10		
12	J. M. Garrison's bed	7	12.25 p. m.	...do...	12	NE....	...do....	0.....	17.2	1.0160	[1] 19	−10	100	2
											15	−10		
13	Semerteen & Lodge's bed	7	1.05	...do...	8	NE....	...do....	0.....	16.8	1.0160	Spr.	−10	450	0
											14	−10		
14	M. B. Devereux's bed	7	1.20	...do...	7	NE....	...do....	0.....	16.6	1.0155	[1] 72	−10	100	1
											39	−10		
15	Frank B. Robbins' bed	7	1.40	...do...	6	NE....	...do....	10.....	16.6	1.0150	[1] Spr.	−10	200	0
											Spr.	−10		
16	John T. Buckson's bed	7	1.55	...do...	6	NE....	...do....	25.....	16.6	1.0145	[1] Spr.	−10	500	1
											Spr.	−10		
17	George H. Carey's bed	7	2.15	Flood.	8	NE....	...do....	25.....	16.6	1.0140	[1] 40	−10	300	2
											Spr.	−10		

[1] From bottom.

TABLE U.—*Analysis of Tables Q, R, S, and T.*

Name of station.	Distance from Philadelphia, Chestnut Street Wharf (nautical miles).	Number of samples.	Per cent of samples showing *B. coli* present in each dilution.						Mean number of B. coli per c. c.	Total count on agar at 37°.			Dissolved oxygen determination.						Number of dissolved oxygen samples.
			C. c. 10.	C. c. 1.	C. c. 0.1.	C. c. 0.01.	C. c. 0.001.	C. c. 0.0001.		Average.	High.	Low.	Per cent saturation.			Loss on incubation, p. p. m.			
													Average.	High.	Low.	Average.	High.	Low.	
Torresdale	8½ above	12	.....	100	92	17	0	0	12.3	785	2,800	[1] 105	78.8	85.2	69.2	0.28	1.20	0	12
Bridesburg	4½ above	12	.....	100	92	50	8	0	31.6	6,626	40,000	[1] 325	71.8	78.2	57.1	.34	1.10	0	12
Coopers Point	0.7 above	9	.....	100	100	100	78	0	603	13,000	33,000	4,000	45.3	66.8	29.2	.60	1.40	.10	12
Kaighn Point	1½ below	13	.....	100	100	61.5	31	7.7	100	5,615	16,000	[1] 265	35.4	53.9	11.6	.43	1.10	0	12
Gloucester Point	2 below	13	.....	100	100	85	15	0	100	8,870	37,000	[1] 165	35.2	49.4	16.3	.52	.85	.20	12
League Island	5.6 below	14	.....	100	93	71.4	36	7	119	16,115	66,000	[1] 240	33.3	44.5	18.6	.38	.80	.10	12
Mifflin Bar [2]	8.3 below	17	.....	100	100	88	29.4	([3])	149	7,278	63,500	[1] 150	34.4	43.4	24.7	.42	1.00	0	12
Tinicum Island	12.5 below	17	.....	100	88.4	47	5.9	0	25.9	3,627	14,000	[1] 165	34.1	49.6	23.5	.34	.80	0	12
Marcus Hook [4]	17.7 below	17	.....	100	82.4	17.6	0	0	10	2,832	16,800	[1] 95	46.7	58.5	32.4	.29	.70	0	12
Gordon Heights [5]	22.2 below	15	.....	100	86.7	6.7	0	0	8.6	3,093	9,900	[1] 100	52.7	59.6	46.0	.29	1.05	0	12
Pigeon Point [6]	26 below	21	95	95	62	5	5	.....	4.2	6,100	59,000	45	68.0	79.5	46.0	.33	.70	0	12
Newcastle	29.7 below	9	89	78	22	0	0	.....	.78	1,420	6,000	25	.....	.....	.....	.....	.....	.....	.....
Delaware City	34 below	7	85.7	85.7	28.6	0	.....	.....	1.0	920	3,930	19	.....	.....	.....	.....	.....	.....	.....
Reedy Island	37¼ below	19	94.7	84	37	0	.....	.....	1.4	1,261	24,000	12	73.7	77.9	68.3	.43	1.10	0	12
Stony Point Shoal	43 below	8	87.5	50	12.5	0	.....	.....	.32	55	88	34	.....	.....	.....	.....	.....	.....	.....
Liston Point	45.5 below	7	43	14	14	0	.....	.....	.05	48	120	10	.....	.....	.....	.....	.....	.....	.....
Arnold Shoal Light	50 below	6	83.3	33.3	0	0	.....	.....	.1	43	95	25	.....	.....	.....	.....	.....	.....	.....
Ship John Light	54.6 below	8	50	0	0	0	.....	.....	.03	36	75	20	.....	.....	.....	.....	.....	.....	.....
Delaware Bay, below Ship John Light, New Jersey side.	Below	69	23.2	7.2	0	.....	.....	.....	.02	26	136	4	.....	.....	.....	.....	.....	.....	.....
Delaware Bay, below East Line, Delaware side.	61 below and over.	34	15	3	0	.....	.....	.....	.015	64	310	5	.....	.....	.....	.....	.....	.....	.....

[1] These low results were all obtained on Dec. 4 and 6 and were uniform, the *B. coli* also giving minimum results for each station.
[2] Cross-section receives both Schuylkill and Delaware pollutions.
[3] Not used.
[4] Receives accessions from Chester and Eddystone on ebb tide.
[5] Receives flood accessions from Christiana Creek, Wilmington.
[6] Receives ebb accessions from Christiana Creek, Wilmington.

TABLE V.—*Maurice River.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.		Dissolved oxygen.			
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.	Per cent saturation.	Parts per million.		
														At once.	24 hours at 20°.	Loss.
		1915.			*Feet.*				°*C.*			*C. c.*				
1	Dock at Millville	Sept. 2	11.40 a. m.	E. last		NE	Fair	0	21.1	1.0000	1,160	[1] + .01	84.1	7.55	7.40	.15
2	Off Millville sewage disposal plant	2	11.55	F. beg.		NE	...do	0	20.5	1.0000	1,030	[1] + .01	80.2	7.20	7.10	.10
3	Off brickyard	2	12.25 p. m.	Flood		NE	...do	0	20.0	1.0000	330	[1] + .1	71.9	6.60	6.55	.05
4	Mouth of Menantico Creek	2	12.35	...do		NE	...do	0	20.0	1.0000	390	[1] + .1	73.6	6.75	.....	.....
5	Off Bricksboro	2	1.20	...do		NE	...do	5	21.1	1.0000	90	[1] + .1	76.3	6.85	6.70	.15
6	Below bridge at Mauricetown	2	1.30	...do		NE	...do	30	21.1	1.0000	72	[1] + .1	76.3	6.85	6.85	.0
7	Off Dorchester	2	1.50	...do		NE	...do	40	21.1	1.0000	116	+ 1	75.8	6.80	6.75	.05
8	Off Leesburg	2	2.10	...do		NE	...do	30	21.1	1.0000	90	+10	74.3	6.65	6.80	+ .15
9	Off Bivalve	2	3.05	...do		NE	...do	10	20.0	1.0080	36	+ 1	87.9	7.65	7.70	+ .05
10	At fish-oil factory	15	4.15	Ebb		SW	...do	60	26.6	.....	343	[1] + .1	101.4	8.25	5.60	2.65
11	At Bivalve	15	6.00	...do		SW	...do	60	26.6	.....	449	+ 1	87.9	7.15	5.80	1.35
12	At mouth	15	6.35	...do		SW	...do	100	26.6	.....	540	+ 1	105.1	8.55	5.70	2.85
13	Dock at Millville	16	4.05	F. last		SW	...do	0	25.5	.....	270	[1] + .1	79.5	6.60	5.30	1.30
14	Below Millville sewage disposal plant outlet.	15	4.10	H. W.		SW	...do	0	25.5	.....	810	[1] + .1	63.8	5.30	4.70	.60
15	Midway between Millville disposal plant and brickyard.	16	4.35	E. beg.		SW	...do	0	26.6	.....	94	+ 1	75.9	6.30	5.30	1.00
16	Opposite brickyard	16	4.45	...do		SW	...do	0	26.6	.....	26	+ 1	81.9	6.80	6.80	.0
17	Below mouth Menantico Creek	16	4.55	...do		SW	...do	5	26.6	.....	80	+10	76.5	6.35	6.25	.10
18	Below mouth Manumuskin Creek	16	5.20	Ebb		SW	...do	10	26.1	.....	22	+ 1	76.2	6.25	5.95	.30
19	Below bridge at Mauricetown	16	5.35	...do		SW	...do	10	26.1	.....	18	+ 1	77.4	6.35	5.70	.65
20	Opposite Dorchester	16	5.50	...do		SW	...do	10	26.1	.....	12	+ 1	70.7	5.80	5.65	.15
21	Opposite Leesburg	16	6.10	...do		SW	...do	20	26.1	.....	25	+ 1	71.9	5.90	5.50	.40
22	Below fish-oil factory	16	6.25	...do		SW	...do	40	26.1	.....	15	+10	69.5	5.70	5.60	.10
23	Bivalve, mid-channel	16	6.45	...do		SW	...do	50	26.1	.....	40	+ 1	75.0	6.15	5.70	.45
24	Mouth	16	7.00	...do		SW	...do	100	26.1	.....	0	+10	76.2	6.25	6.00	.25
25	Bivalve, at shucking house	28	1.15	E. beg.	16	None	...do	10	17.2	1.0110	159	+ 1	.....	.....	.....	.....
26	.....do	28	1.45	Ebb	16	...do	...do	10	17.2	1.0110	74	+10	.....	.....	.....	.....
27	.....do	28	2.15	...do	15	...do	...do	10	17.2	1.0105	65	+ 1	.....	.....	.....	.....
28	.....do	28	2.45	...do	15	...do	...do	10	17.2	1.0100	165	+ 1	.....	.....	.....	.....
29	.....do	28	3.15	...do	14	...do	...do	10	17.7	1.0080	33	[1] + .1	.....	.....	.....	.....
30	.....do	28	3.45	...do	14	...do	...do	10	18.3	1.0070	156	+ 1	.....	.....	.....	.....
31	.....do	28	4.15	...do	13	...do	...do	10	18.3	1.0055	120	+ 1	.....	.....	.....	.....
32	.....do	28	4.45	...do	13	...do	...do	10	18.3	1.0040	119	[1] + .1	.....	.....	.....	.....
33	.....do	29	5.15	...do	12	...do	...do	10	18.3	1.0040	196	[1] + .1	.....	.....	.....	.....

34	.....do		28	5.45	...do...	12	...do...	...do.....	20	18.3	1.0025	91	+ 1				
35	.....do		28	6.15	...do...	11	...do...	...do.....	30	18.3	1.0020	195	+ 1				
36	.....do		28	6.45	...do...	11	...do...	...do.....	30	17.7	1.0015	12	+ 1				
37	.....do		28	7.15	E.last.	11	...do...	...do.....	30	18.3	1.0010	98	+ 1				
38	.....do		28	1.15	E.beg.	16	...do...	...do.....	10	17.2	1.0110	[2] 99	+10				
39	.....do		28	1.45	Ebb...	16	...do...	...do.....	10	17.2	1.0110	[2] 262	+10				
40	.....do		28	2.15	...do...	15	...do...	...do.....	10	17.2	1.0105	[2] 300	+ 1				
41	.....do		28	2.45	...do...	15	...do...	...do.....	10	17.2	1.0100	[2] 114	+ 1				
42	.....do		28	3.15	...do...	14	...do...	...do.....	10	17.7	1.0080	[2] 62	+ 1				
43	.....do		28	3.45	...do...	14	...do...	...do.....	10	18.3	1.0070	[2] 125	[1] + .1				
44	.....do		28	4.15	...do...	13	...do...	...do.....	10	18.3	1.0055	[2] 160	[1] + .1				
45	.....do		28	4.45	...do...	13	...do...	...do.....	10	18.3	1.0040	[2] 540	+ 1				
46	.....do		28	5.15	...do...	12	...do...	...do.....	10	18.3	1.0040	[2] 65	+ 1				
47	.....do		28	5.45	...do...	12	...do...	...do.....	20	18.3	1.0025	[2] 58	[1] + .1				
48	.....do		28	6.15	...do...	11	...do...	...do.....	30	18.3	1.0020	[2] 131	+ 1				
49	.....do		28	6.45	...do...	11	...do...	...do.....	30	17.7	1.0015	[2] 150	+ 1				
50	.....do		28	7.15	E.last.	11	...do...	...do.....	30	18.3	1.0010	[2] 15	+ 1				
51	Mid-channel opposite Bivalve....		30	6.45 a. m.	Ebb..	11	NE....	...do.....	5	17.5	1.0030	40	+ 1				
52	.....do		30	7.00	...do...	10	NE....	...do.....	5	17.7	1.0030	110	+ 1				
53	.....do		30	7.15	...do...	10	NE....	...do.....	5	18.0	1.0025	75	+10				
54	.....do		30	7.30	...do...	10	NE....	...do.....	5	18.0	1.0025	Spr.	+ 1				
55	.....do		30	7.45	...do...	9	NE....	...do.....	5	18.0	1.0020	75	+ 1				
56	.....do		30	8.00	E.last.	9	NE....	...do.....	5	18.0	1.0025	255	[1] + .1				
57	.....do		30	2.45 p. m.	E.beg.	15	W.....	...do.....	5	16.9	1.0115	215	+ 1				
58	.....do		30	3.15	Ebb..	15	W.....	...do.....	5	16.3	1.0110	140	+ 1				
59	.....do		30	3.45	...do...	14	W.....	...do.....	5	16.6	1.0105	200	+ 1				
60	.....do		30	4.15	...do...	14	W.....	...do.....	5	16.6	1.0100	130	+ 1				
61	.....do		30	4.45	...do...	13	W.....	...do.....	5	16.6	1.0095	195	+10				
62	.....do		30	5.15	...do...	13	W.....	...do.....	5	16.6	1.0085	140	+ 1				
63	.....do		30	5.45	...do...	12	W.....	...do.....	5	16.6	1.0080	185	+10				
64	.....do		30	6.15	...do...	12	W.....	...do.....	5	17.2	1.0070	120	+10				
65	.....do		30	6.45	...do...	11	W.....	...do.....	10	17.2	1.0065	65	[1] + .1				
66	.....do		30	7.15	...do...	11	None..	...do.....	....	17.2	1.0060	145	+ 1				
67	.....do		30	7.45	...do...	10	...do...	...do.....	....	17.2	1.0055	195	+ 1				
68	.....do		30	8.15	...do...	10	...do...	...do.....	....	17.7	1.0050	70	[1] + .1				
69	.....do		30	8.45	E.last.	9	...do...	...do.....	....	17.7	1.0040	190	+ 1				
70	.....do	Oct.	26	3.45	Ebb..	11	S......	...do.....	75	15.5	1.0050	....	[1] + .1				
71	.....do		26	4.15	...do...	11	S......	...do.....	75	15.5	1.0025	....	+ 1				
72	.....do		26	5.30	...do...	10	S......	...do.....	75	15.00	1.0015	....	[1] + .1				
73	.....do		26	6.00	...do...	9	S......	...do.....	50	15.05	1.0005	....	+ 1				
74	.....do		26	6.30	L. W..	9	S......	Cloudy..	10	15.5	1.0005	....	+ 1				
75	Manumuskin Creek, above bridge at Port Elizabeth.		28	3.30	Ebb..	....	None..	Fair.....	Moderate	15.00	1.0000	....	+ 1				
76	.....do		28	3.40	...do...	....	...do...	...do.....	Moderate	15.0	1.0000	....	[1] + .1				
77	Manumuskin Creek, midway between 76 and 78.		28	3.50	...do...	....	...do...	...do.....	Moderate	15.0	1.0000	....	[1] + .1				
78	Manumuskin Creek at mouth....		28	4.00	...do...	....	...do...	...do.....	Moderate	15.0	1.0000	....	[1] + .1				
79	Above mouth of Manumuskin Creek.		28	4.10	...do...	....	...do...	...do.....	Moderate	15.0	1.0000	....	+ 1				
80	.....do		28	4.15	...do...	....	...do...	...do.....	Moderate	15.	1.0000	....	+ 1				

[1] Highest dilution planted.
[2] From bottom.

TABLE V.—*Maurice River*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.		Dissolved oxygen.			
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.	Per cent saturation.	Parts per million.		
														At once.	24 hours at 20°.	Loss.
		1915.			*Feet.*				° *C.*			*C. c.*				
81	400 feet above mouth of Manumuskin Creek.	Nov. 2	1.25	Ebb	.....	NW	Fair	.....	.....	.....	78	[1] + .1	.....	.....	.....	.....
82	200 feet above mouth of Manumuskin Creek.	2	1.30	do	.....	NW	do	.....	.....	.....	56	+ 1	.....	.....	.....	.....
83	Manumuskin Creek below Port Elizabeth.	2	1.35	do	.....	NW	do	.....	.....	.....	270	+ 1	.....	.....	.....	.....
84	Manumuskin Creek 2 miles above Port Elizabeth.	2	2.00	do	.....	NW	do	.....	.....	.....	173	+10	.....	.....	.....	.....
85	Menantico Creek above sand washer at railroad crossing.	2	4.00	(2)	2	NW	do	0	15.5	1.0000	77	+10	.....	.....	.....	.....
86	do	2	4.00	(2)	2	NW	do	0	15.5	1.0000	14	+10	.....	.....	.....	.....
87	Menantico Creek below W. J. & S. R. R. bridge.	2	4.05	(2)	2	NW	do	0	15.5	1.0000	57	+10	.....	.....	.....	.....
88	Menantico Creek about 300 yards below No. 87.	2	4.10	(2)	3	NW	do	0	15.5	1.0000	86	+10	.....	.....	.....	.....
89	Manumuskin Creek 2 miles above railroad.	3	4.35	(2)	1	NW	do	0	15.0	1.0000	120	+10	.....	.....	.....	.....
90	Manumuskin Creek 1 mile above railroad.	3	4.55	(2)	1	NW	do	0	15.0	1.0000	124	+ 1	.....	.....	.....	.....
91	do	3	4.55	(2)	1	NW	do	0	15.0	1.0000	112	−10	.....	.....	.....	.....
92	Manumuskin Creek at W. J. & S. bridge.	3	5.20 p. m.	Flood.	3	None	do	0	15.0	1.0000	127	+ 1	.....	.....	.....	.....
93	Gravelly Run above dam	4	8.30 a. m.	(2)	2	do	do	0	14.4	1.0000	84	+10	.....	.....	.....	.....
94	do	4	8.30	(2)	2	do	do	0	14.4	1.0000	98	+10	.....	.....	.....	.....
95	do	4	8.40	Ebb	5	do	do	5	14.4	1.0000	390	[1] + .1	.....	.....	.....	.....
96	do	4	8.40	do	5	do	do	5	14.4	1.0000	320	[1] + .1	.....	.....	.....	.....
97	Gravelly Run, mill race	4	8.45	(2)	1	do	do	0	14.4	1.0000	62	−10	.....	.....	.....	.....
98	do	4	8.45	(2)	1	do	do	0	14.4	1.0000	114	+10	.....	.....	.....	.....
99	Below dam at Union Lake	4	9.30	do	1	do	do	5	14.4	1.0000	Spr.	[1] + .1	.....	.....	.....	.....
100	Union Lake at spillway	4	9.40	(2)	.....	do	do	0	14.4	1.0000	Spr.	−10	.....	.....	.....	.....
101	Union Lake along dam about middle.	4	9.45	(2)	.....	do	do	0	14.4	1.0000	43	−10	.....	.....	.....	.....
102	Union Lake near mill race	4	10.00	(2)	.....	do	do	0	14.4	1.0000	51	+ 1	.....	.....	.....	.....
103	Menantico Creek, above sand washer at railroad bridge.	4	2.40 p. m.	(2)	2	S	Cloudy	0	14.4	1.0000	298	+ 1	.....	.....	.....	.....

104	Menantico Creek, about 1 mile below W. J. & S. bridge.		4	3.30	Ebb	2	S	do		25	14.4	1.0000	270	+ 1					
105	Menantico Creek at railroad bridge		4	4.05	(2)	2	S	do		0	14.4	1.0000	133	+ 1					
106	Manumuskin Creek, 1 mile above railroad bridge.		4	5.05	(2)	1	S	do		0	14.4	1.0000	140	[1] + .1					
107	do		4	5.05	(2)	1	S	do		0	14.4	1.0000	168	+ 1					
108	Manumuskin Creek, at railroad bridge.		4	5.20	Flood	3	S	Rain		5	14.4	1.0000	300	[1] + .1					
109	Dock below bridge at Millville	Dec.	11	8.00 a. m.	Ebb		NW	Fair			.5		40	+ 1					
110	Below sewage-disposal plant		11	8.20	do		NW	do		5	.5		50	[1] + .01					
111	Between sewage-disposal plant and brickyard.		11	8.40	do		NW	do		5	.5		130	[1] + .01					
112	Brickyard		11	9.00	do		NW	do		5	.5		133	+ .1					
113	Menantico Creek		11	9.20	E. last		NW	do		5	.5		105	[1] + .01					
114	Mouth of Manumuskin Creek		11	9.40	F. beg		NW	do		10	.5		80	+ .1					
115	Mauricetown, above bridge		11	10.20	Flood		NW	do		25	.5		68	+ 1					
116	Dorchester		11	10.35	do		NW	do		25	1.1		66	+ 1					
117	Between Dorchester and Leesburg		11	10.45	do		NW	do		25	1.1		53	− 1					
118	Leesburg		11	10.00	do		NW	do		25	1.6		78	+ 1					
119	Fish oil factory		11	11.20	do		NW	do		25	1.6		86	+ 1					
120	Between 119 and 121		11	11.40	do		NW	do		25	1.6		72	+ 1					
121	Bivalve, shucking house		11	12.00 m.	do	14	NW	do		25	1.6		66	+ 1					
122	do		13	7.30 a. m.	Ebb	16	NE	Stormy		40	2.7		38	+ 1					
123	do		13	8.00	do	15	NE	do		30	2.7		130	+ .1					
124	do		13	8.30	do	15	NE	do		25	2.7		95	+ 1					
125	do		13	9.00	do	14	NE	do		25	2.7		138	− 1					
126	do		13	9.30	do	14	NE	do		25	2.7		158	+ 1					
127	do		13	10.00	do	13	NE	do		25	2.7		163	− 1					
128	do		13	10.30	do	13	NE	do		25	2.7		200	− 1					
129	do		13	11.30	L. W	11	NE	do		25	2.7		188	+ 1					
130	do		13	1.30 p. m.	Flood	12		do		40	2.7		95	− 1					
131	do		13	2.30	do	13	NE	do		40	2.7		115	+ 1					
132	do		13	3.30	do	14	NE	do		50	2.7		80	+ .1					
133	do		14	6.30	Ebb	16	NW	Cloudy		15	1.6		110	+10					
134	do		14	7.00	do	16	NW	do		25	1.6		92	+10					
135	do		14	7.30	do	15	NW	do		25	1.6		77	+ 1					
136	do		14	8.00	do	15	NW	do		20	1.6		110	+10					
137	do		14	8.30 a. m.	do	14	NW	do		20	1.6		126	[1] + .1					
138	do		14	9.00	do	14	NW	do		35	1.6		171	[1] + .1					
139	do		14	9.30	do	13	NW	do		25	1.6		149	+10					
140	do		14	10.00	do	13	NW	do		25	1.6		170	+10					
141	do		14	10.30	do	12	NW	do		20	1.6		210	+10					
142	do		14	11.00	do	12	NW	do		20	1.6		181	+ 1					
143	do		14	11.30	E. last	11	NW	do		20	1.6		190	+10					
144	do		14	12.30 p. m.	F. beg	11	NW	do		25	1.6		203	−10					
145	do		14	1.30	Flood	12	NW	do		30	1.6		172	+10					
146	do		14	2.30	do	13	NW	do		30	1.6		120	+ 1					
147	do		15	7.00 a. m.	Ebb	16	None	Fair		35	.05		110	+10					
148	do		16	7.30	do	16	do	do		35	.05		35	+10					
149	do		16	8.00	do	15	do	do		35	.05		131	−10					

[2] Above tidewater.

[1] Highest dilution planted.

TABLE V.—*Maurice River*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth of water.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.		Dissolved oxygen.			
											Number colonies per c. c., agar 37°, 48 hours.	B. coli.	Per cent saturation.	Parts per million.		
														At once. MeMM	24 hours at 20°.	Loss.
		1915.			*Feet.*				° *C.*			*C. c.*				
150	Bivalve,s hucking house	Dec. 16	8.30	Ebb ..	15	None..	Fair.....	35	.05	.....	96	+ 1	.....	.....	.....	.....
151	.....do.....	16	9.00	...do...	14	...do...	...do.....	35	.05	.....	76	+10	.....	.....	.....	.....
152	.....do.....	16	9.30	...do...	14	...do...	...do.....	35	.05	.....	62	−10	.....	.....	.....	.....
153	.....do.....	16	10.00	...do...	13	...do...	...do.....	35	.05	.....	74	+ 1	.....	.....	.....	.....
154	.....do.....	16	10.30	...do...	13	...do...	...do.....	35	.05	.....	156	+10	.....	.....	.....	.....
155	.....do.....	16	11.00	...do...	12	...do...	...do.....	35	.05	.....	110	+10	.....	.....	.....	.....
156	.....do.....	16	11.30	...do...	12	...do...	...do.....	35	.05	.....	130	+10	.....	.....	.....	.....
157	Midway between Bivalve and mouth.	16	1.00 p. m.	...do...	19	...do...	...do.....	35	1.1	.....	76	+10	.....	.....	.....	.....

TABLE W.—*Maurice River: Summary of results obtained from three series of samples from Millville to mouth of river.*

Name of station.	Distance from Millville.	Number samples.	Per cent of samples showing B. coli present in each dilution.					Mean number of B. coli per c.c.	Total count on agar at 37° C.			Dissolved oxygen determinations.						
			C.c. 10.	C.c. 1.	C.c. 0.1.	C.c. .01.	C.c. .001.		Average.	High.	Low.	Number of samples.	Per cent saturation.			Loss on incubation p. p. m.		
													Average.	High.	Low.	Average.	High	Low.
	Nautical miles.																	
Millville Dock	0	3	100	100	67	33	0	10.0	490	1,160	40	7	80.9	84.8	76.3	0.52	1.30	0.10
Millville sewage disposal plant	0.75	3	100	100	100	67	0	46.8	630	1,030	50	5	73.8	78.6	63.8	.60	.60	.60
Between disposal plant and brickyard	2.25	2	100	100	50	50	0	10.0	112	130	94	5	79.1	81.7	75.9	1.00	1.00	1.00
Off brickyard	3.50	3	100	100	67	0	0	4.7	163	330	26	6	78.4	81.9	71.9	.02	.05	.00
Mouth of Menantico Creek	5.25	3	100	67	67	33	0	4.7	192	390	80	2	75.1	76.5	73.6	.10	.10	.10
Manamuskin Creek	8.75	5	100	100	40	0	0	2.5	51	80	22	5	76.7	78.0	75.2	.30	.30	.30
Bricksboro	9.75	1	100	100	100	0	0	10.0	90	90	90	5	76.0	77.0	74.9	.15	.15	.15
Below bridge at Mauricetown	11.00	3	100	100	33	0	0	2.1	53	72	18	5	76.1	77.6	73.5	.32	.65	.00
Dorchester	12.00	3	100	100	0	0	0	1.0	65	116	12	5	75.2	77.6	70.7	.10	.15	.05
Leesburg	14.00	3	100	67	0	0	0	.47	64	90	25	5	75.0	77.3	71.9	.12	.40	+ .15
Menhaden fish, oil factory	15.00	3	100	67	33	0	0	1.0	175	449	36	5	79.2	101.4	69.5	1.37	2.65	.10
Bivalve	17.00	3	100	100	20	0	0	1.0	205	540	36	6	79.8	87.9	74.9	.87	1.35	+ .05
Mouth of Maurice River	20.00	3	100	33	0	0	0	.2	270	540	0	5	82.8	105.1	76.2	1.55	2.85	.25

TABLE X.—*Samples of "floated" oysters, Maurice River, at Bivalve and Maurice River.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Number colonies per c. c. on agar 37° 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			
1	Float of A. D. Campbell	Sept. 2	4.00 p. m.	Flood	13	None	Fair		20.0	1.0080	5,500	1
2	Float of Covert & Lee	2	4.05	do	13	do	do		20.0	1.0080	2,100	1
3	Float of Bateman & Blizzard	2	4.10	do	13	do	do		20.0	1.0080	2,600	2
4	Float of Berry & Hiles	2	4.15	do	13	do	do		20.0	1.0080	6,400	2
5	John Gaskins shipping house	16	10.00 a. m.								4,250	5
6	Mulford & Mulford shipping house	16	10.00								16,500	4
7	Morris & Fowler shipping house	16	10.00								1,450	0
8	A. D. Campbell	16	10.00								350	1
9	Sheppard Campbell shipping house	16	10.00								4,600	4
10	R. L. Bateman & Sons shipping house	16	10.00								6,900	41
11	Luther Bateman shipping house	16	10.00								5,500	3
12	C. W. Hand shipping house	16	10.00								22,350	23
13	do	17	11.00								123,000	5
14	Berry & Hiles shipping house	17	11.00								24,300	1
15	Mulford & Mulford shipping house	17	11.00								29,400	2
16	do	17	11.00								26,700	1
17	T. A. Rogers shipping house	17	11.00								33,000	23
18	Newcomb Bros. shipping house	17	11.00								285,000	3
19	Bateman & Blizzard shipping house	17	11.00								23,400	0
20	P. Campbell shipping house	17	11.00								84,000	32
21	Floated one "low water" bivalve side	21	7.00 a. m.	F. last	14	SW	Rain				63,000	32
22	do	21	7.00	do	14	SW	do				45,000	5
23	do	21	7.00	do	14	SW	do				105,000	5
24	do	21	7.00	do	14	SW	do				138,000	3
25	do	21	7.00	do	14	SW	do				13,000	23
26	do	21	7.00	do	14	SW	do				51,000	5
27	Floated 3 "low water" bivalve side	22	9.00	do	14	NW	Fair				100	5
28	do	22	9.00	do	14	NW	do				0	2
29	do	22	9.00	do	14	NW	do				200	2
30	do	22	9.00	do	14	NW	do				150	3
31	do	22	9.00	do	14	NW	do				100	0
32	do	22	9.00	do	14	NW	do				150	0
33	Floated 1 "low water" Bivalve side	23	8.30	do	14	None	do				2,450	5
34	do	23	8.30	do	14	do	do				8,650	41
35	do	23	8.30	do	14	do	do				4,700	4
36	do	23	8.30	do	14	do	do				8,350	41
37	do	23	8.30	do	14	do	do				2,050	2
38	do	23	8.30	do	14	do	do				6,150	5
39	Floated 2 "low water' Bivalve side	23	4.30 p. m.	F. beg.	9	do	do				78,000	1
40	do	23	4.30	do	9	do	do				60,000	1

41	....do		23	4.30	...do	9	...do	...do					186,000	23
42	....do		23	4.30	...do	9	...do	...do					57,000	3
43	....do		23	4.30	...do	9	...do	...do					42,000	1
44	....do		23	4.30	...do	9	...do	...do					48,000	2
45	....do		30	10.00 a. m.	...do	9	NE	...do					6,000	1
46	....do		30	10.00	...do	9	NE	...do					5,900	0
47	....do		30	10.00	...do	9	NE	...do					1,295	1
48	....do		30	10.00	...do	9	NE	...do					4,200	2
49	....do		30	10.00	...do	9	NE	...do					4,500	0
50	....do		30	10.00	...do	9	NE	...do					3,950	4
51	....do		30	10.00	...do	9	NE	...do					12,500	0
52	....do		30	10.00	...do	9	NE	...do					18,000	3
53	....do		30	10.00	...do	9	NE	...do					4,400	5
54	....do		30	10.00 a. m.	...do	9	NE	...do					4,800	1
55	....do		30	10.00	...do	9	NE	...do					1,350	14
56	John Gaskin's shipping house	Oct.	1	10.30			NE						400	23
57	Sheppard Campbell shipping house		1	10.30			NE						300	4
58	Luther Bateman shipping house		1	10.30			NE						400	32
59	P. Campbell shipping house		1	10.30			NE						300	23
60	Ogden Candy shipping house		1	10.30			NE						1,400	41
61	....do		1	10.30			NE						1,500	4
62	Hageman & Pole shipping house		1	10.30			NE						800	5
63	T. A. Rogers shipping house		1	10.30			NE						300	4
64	Float at Bivalve [1]		4	11.30	L. W.	13	SE	Fair					19,500	23
65	....do		4	11.30	...do	13	SE	...do					19,500	23
66	....do		4	11.30	...do	13	SE	...do					22,500	41
67	....do		4	11.30	...do	13	SE	...do					19,500	32
68	....do		4	11.30	...do	13	SE	...do					14,900	320
69	....do		4	11.30	...do	13	SE	...do					10,500	320
70	Sockwell shipping house [2]	Nov.	9	11.30									45,300	5
71	....do		9	11.30									27,600	32
72	....do		9	11.30									51,900	32
73	....do		9	11.30									35,700	4
74	....do		9	11.30									23,400	4
75	Oyster barge, floated 4 days	Dec.	9	2.00 p. m.									370	[3] 0
76	....do		9	2.00									1,520	[3] 0
77	Oyster barge, floated 3 or 4 days		9	2.00									700	[3] 1
78	....do		9	2.00									440	[3] 0
79	Oyster barge, floated 4 days		9	2.00									110	[3] 1
80	Oyster barge, floated 3 or 4 days		9	2.00									350	[3] 0
81	....do		9	2.00									825	[3] 3
82	Oyster barge, floated 3 days		13	10.00 a. m.									315	[3] 0
83	Oyster barge, floated 4 days		13	10.10									450	[3] 1
84	Oyster barge, floated 3 or 4 days		13	10.00									715	[3] 5
85	....do		13	10.00									2,600	[3] 1
86	....do		13	10.10									1,040	[3] 1
87	....do		13	10.10									460	[3] 2
88	....do		13	10.00									6,000	[3] 0

[1] A few scattered oysters lying in empty float. Length of time floated not known.
[2] Samples taken from shipment of oysters ready to be sent to New York City.
[3] Weather cold. Temperature of water low.

TABLE X.—*Samples of "floated" oysters, Maurice River, at Bivalve and Maurice River*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Depth.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Number colonies per c. c. on agar 37° 48 hours.	Score based on B. coli in shell liquor.
		1915.			*Feet.*				°*C.*			
89	.....do.....	13	10.00	.....	.....	.....	.....	.....	.....	.....	1,275	[1] 1
90	.....do.....	13	10.00	.....	.....	.....	.....	.....	.....	.....	2,400	[1] 0
91	.....do.....	13	10.00	.....	.....	.....	.....	.....	.....	.....	1,280	[1] 0
92	.....do.....	16	11.00	.....	.....	.....	.....	.....	.....	.....	380	[1] 1
93	.....do.....	16	11.00	.....	.....	.....	.....	.....	.....	.....	2,500	[1] 1
94	.....do.....	16	11.00	.....	.....	.....	.....	.....	.....	.....	270	[1] 1
95	.....do.....	16	11.00	.....	.....	.....	.....	.....	.....	.....	280	[1] 3
96	.....do.....	16	11.00	.....	.....	.....	.....	.....	.....	.....	90	[1] 0

[1] Weather cold. Temperature of water low.

TABLE Y.—*Cohansey River.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.		Dissolved oxygen.			
										Number colonies per c. c. agar 37° 48 hours.	B. coli.	Per cent saturation.	Parts per million.		Loss.
													At once.	24 hours at 20°.	
		1915.						° C.			C. c.				
1a	Greenwich Pier	Oct. 5	2.00 p. m.	L. W.	None	Fair				175	[1] + 0.1				
1	do	14	8.00 a. m.	Ebb	E	Cloudy	5	16.6	1.0080	570	+ 1	106.7	9.90	10.00	+0.10
2	Laning Wharf	14	8.30	do	E	do	5	17.2	1.0070	670	[1] + .1	105.2	9.70	9.80	+ .05
3	Fourth reach above Laning Wharf	14	9.00	E. last	E	do	5	16.6	1.0065	Spr.	[1] + .1	105.0	9.85	9.40	.45
4	Opposite residence of John Wetherell	14	9.30	F. beg.	E	do	5	16.6	1.0060	475	[1] + .1	103.0	9.70	7.75	1.95
5	Third reach above Wetherell's	14	10.00	Flood	E	do	5	16.1	1.0050	430	+ 1	102.8	9.85	8.00	1.85
6	Opposite island below Fairton	14	10.30	do	E	do	50	16.6	1.0025	900	[1] + .1	104.3	10.10	7.95	2.15
7	Fairton	14	11.00	do	E	do	50	16.6	1.0000	Spr.	[1] + .1	96.1	9.45	7.65	1.80
8	Lower end of Bridgeton	14	11.30	do	E	do		16.6	1.0000	1,220	[1] + .1	63.5	6.25	4.15	2.10
9	Between lower and middle bridges, Bridgeton.	14	12.30 p. m.	do	E	do		17.7	1.0000	18,300	[1] + .1	75.0	7.20	.55	6.65
10	Above Bridgeton	14	12.00 m.	do	E	do		17.7	1.0000	1,025	[1] + .1	98.4	9.45	7.40	2.05
11	Greenwich Pier	14	8.45 a. m.	Ebb	SE	Fair	15	17.7	1.0000	810	+ 1				
12	do	15	8.00	do	None	Foggy	30	16.9	1.0040	140	+ 1				
13	do	15	8.20	do	do	do	30	16.9	1.0025	125	+ 1				
14	do	15	9.00	do	do	do	30	17.7	1.0025	150	+ 1				
15	do	15	9.30	E. last	do	Cloudy	30	17.2	1.0020	210	+10				
16	do	15	10.00	L. W.	do	do	30	16.9	1.0020	140	+ 1				
17	Halfway between mouth and Greenwich Pier.	15	11.50	Flood	do	do	5	16.6	1.0060	105	+10	109.9	10.35		
18	Mouth	15	12.15 p. m.	do	do	do	5	16.6	1.0100	55	[1] + .1	122.9	11.15		
19	Greenwich Pier	19	8.00 a. m.	F. beg.	S	Fair	10	16.9	1.0100	75	+ 1				
20	do	19	8.30	Ebb	S	do	10	16.6	1.0095	60	+ 1				
21	do	19	9.00	do	S	do	10	16.9	1.0090	60	+ 1				
22	do	19	9.30	do	S	do	5	16.6	1.0085	75	+ 1				
23	do	19	10.00	do	S	do	20	17.2	1.0080	135	+ 1				
24	do	19	10.30	do	S	do	30	17.2	1.0075	120	+ 1				
25	do	19	11.00	do	S	do	20	17.2	1.0055	30	[1] + .1				
26	do	19	11.30	do	S	do	30	17.2	1.0050	150	+ 1				
27	do	19	12.00 m.	do	S	do	5	17.2	1.0040	230	[1] + .1				
28	do	19	12.30	do	S	do	5	17.2	1.0040	210	[1] + .1				

[1] Highest dilution planted.

TABLE Y.—*Cohansey River*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Wind.	Weather.	Turbidity.	Temperature.	Salinometer reading.	Bacteria in water.		Dissolved oxygen.			
										Number colonies per c. c. agar 37° 48 hours.	B. coli.	Parts per million.			Loss.
												Per cent saturation.	At once.	24 hours at 20°.	
								° C.			C. c.				
29	Greenwich Pier	19	1.00 p. m.	Ebb	S	Fair	5	17.7	1.0035	185	[1]+ .1				
30	do	19	1.30	do	S	do	5	17.7	1.0025	440	+ 1				
31	do	19	2.00	do	S	do	5	17.7	1.0020	250	[1]+ .1				
32	do	19	2.30	L. W.	S	do	5	17.7	1.0030	310	+ 1				
32b	do	23	6.00 a. m.	F. beg.	N	do				85	−10				
33	Above railroad bridge, Bridgeton	Nov. 9	2.45 p. m.	Ebb	NW	do				2,140	[1]+ .01				
34	Between two lower bridges at Bridgeton.	9	3.05	do	NW	do				1,890	[1]+ .01				
35	Lower end of Bridgeton	9	3.15	do	NW	do				620	+ .1				
36	Opposite Fairton	9	3.30	do	NW	do				360	+ .1				
37	Island below Fairton	9	3.45	do	NW	do				420	+ .1				
38	Third reach above Wetherell's	9	4.00	do	NW	do				210	[1]+ .01				
39	Opposite John Wetherell's residence	9	4.15	do	NW	do				420	+ .1				
40	Fourth ranch above Laning Wharf	9	4.30	do	NW	do				300	+ 1				
41	Laning Wharf	9	4.45	do	NW	do				450	+ 1				
42	Greenwich Pier	9	5.00	do	NW	do				480	+ .1				
43	Fourth reach above Laning Wharf	Dec. 20	1.40 p. m.	do	N	Cloudy	15	1.1		80	− 1				
44	Third reach above Wetherell's	20	2.00	do	N	do	20	1.1		150	+ 1				
45	Island below Fairton	20	2.30	do	N	do	15	1.1		180	+ 1				
46	Below Fairton	20	2.55	do	N	do	15	1.1		500	+ .1				
47	Three miles below Bridgeton	20	3.10	do	N	do	15	1.1		450	[1]+ .01				
48	One mile below Bridgeton	20	3.20	do	N	do	5	1.1		470	+ .001				
49	Opposite gas plant at Bridgeton	20	3.25	do	N	do	5	1.6		415	+ .01				
50	Lower bridge, Bridgeton	20	3.30	do	N	do	5	1.6		425	+ .001				
51	Greenwich Pier	17	11.30 a. m.	do	N	do		.05		53	+10				
52	do	17	12.00	do	N	do		.05		65	−10				
53	do	17	12.30	do	N	do		.05		82	+10				
54	do	17	1.00 p. m.	do	N	do		.05		100	+10				
55	do	17	1.30	do	N	do		.05		68	+10				
56	do	17	2.00	do	N	do		.05		64	+10				
57	do	17	2.30	L. W.	N	do		.05		82	+10				

[1] Highest dilution planted.

TABLE Z.—*Samples of "floated" oysters, Cohansey River.*

No.	Location of sampling station.	Date.	Hour.	Tide.	Wind.	Weather.	Turbidity.	Temperature.	Number of colonies per c. c. on agar 37° 48 hours.	Score based in *B. coli* on shell liquor.
		1915						°C.		
1	Float at Greenwich Pier	Oct. 5	2.00 p. m.	E. Last	None	Fair			0	2
2	....do	5	2.00	...do	...do	...do			100	3
3	....do	5	2.00	...do	...do	...do			100	41
4	....do	5	2.00	...do	...do	...do			250	2
5	Float of William Shillingsburg	14	9.00 a. m.	L. W	E	...do	5	16.6	90,000	410
6	Float of P. W. Williams	14	9.05	...do	E	...do	5	16.6	72,000	3
7	Float of Chris. Johnson	14	9.10	...do	E	...do	5	16.6	30,000	5
8	Float of Thomas Cooney	14	9.25	...do	E	...do	5	16.6	9,650	4
9	Float of Chris. Johnson	14	9.30	...do	E	...do	5	16.6	3,200	3
10	Float of William P. Williams	14	10.00	F. beg.	E	...do	5	16.6	9,450	5
11	....do	14	10.05	Flood	E	...do	5	16.6	4,100	3
12	....do	14	10.10	...do	E	...do	5	16.6	7,750	32
13	Float of William Shillingsburg	14	10 15	...do	E	...do	5	16.6	6,100	14
14	....do	14	10.20	...do	E	...do	5	16.6	4,800	23
15	....do	15	10.30	L. W	None	Cloudy	30	17.3	200	14
16	Float of Chris. Johnson	15	10.35	...do	...do	...do	30	17.3	5,700	32
17	....do	15	10.38	...do	...do	...do	30	17.3	12,650	5
18	Float of William P. Williams	15	10.40	...do	...do	...do	30	17.3	9,100	3
19	....do	15	10.45	...do	...do	...do	30	17.3	4,100	4
20	....do	15	10.50	...do	...do	...do	30	17.3	57,000	5
21	Float of William Shillingsburg	19	2.30 p. m.	...do	S	Fair	5	17.7	400	23
22	....do	19	2.30	...do	S	...do	5	17.7	2,100	5
23	....do	19	2.30	...do	S	...do	5	17.7	800	4
24	....do	19	2.30	...do	S	...do	5	17.7	2,900	2
25	Lower floats at Greenwich	19	2.30	...do	S	...do	5	17.7	400	0
26	....do	19	2.30	...do	S	...do	5	17.7	710	2
27	....do	19	2.30	...do	S	...do	5	17.7	910	1
28	....do	19	2.30	...do	S	...do	5	17.7	Spr.	1
29	....do	19	2.30	...do	S	...do	5	17.7	1,420	1
30	....do	19	2.30	...do	S	...do	5	17.7	1,190	5
31	Float of William Shillingsburg [1]	23	6.00 a. m.	F. beg.	N	...do				3
32	....do.[1]	23	6.00	...do	N	...do				14
33	....do.[1]	23	6.00	...do	N	...do				5
34	....do.[1]	23	6.00	...do	N	...do				4
35	....do.[1]	23	6.00	...do	N	...do				23
36	....do.[1]	23	6.00	...do	N	...do				41
37	....do.[1]	23	6.00	...do	N	...do				23

[1] From scow load taken up about 12 hours previous to time of collection of samples.

TABLE Z.—*Samples of "floating" oysters, Cohansey River*—Continued.

No.	Location of sampling station.	Date.	Hour.	Tide.	Wind.	Weather.	Turbidity.	Temperature.	Number of colonies per c. c. on agar 37° 48 hours.	Score based on *B. coli* in shell liquor.
		1915						°C.		
38	Lower floats at Greenwich [1]	Oct. 23	6.00	F. beg.	N	Fair				14
39	do.[1]	23	6.00	do	N	do				5
40	do.[1]	23	6.00	do	N	do				4
41	Float of William Shillingsburg	Dec. 17	10.00	L. W	N	Cloudy[2]		0	110	3
42	do	17	10.00	do	N	do		0	80	3
43	do	17	10,00	do	N	do		0	100	0
44	do	17	10.00	do	N	do		0	90	1
45	do	17	10.00	do	N	do		0	390	320
46	do	17	10.00	do	N	do		0	205	14
47	do	17	10.00	do	N	do		0	330	5
48	do	17	10.00	do	N	do		0	245	3
49	do	17	10.00	do	N	do		0	210	0
50	do	17	10.00	do	N	do		0	190	5
51	do	20	7.00 p. m.	Flood	N	do		1.1	560	5
52	do	20	7.00	do	N	do		1.1	600	4
53	do	20	7.00	do	N	do		1.1	490	3
54	do	20	7.00	do	N	do		1.1	420	0
55	do	20	7.00	do	N	do		1.1	1,080	0
56	do	20	7.00	do	N	do		1.1	290	0
57	do	20	7.00	do	N	do		1.1	640	2

[1] From scow load taken up about 12 hours previous to time of collection of samples.

[2] Very cold; temperature of water 0 to 3° C. most of time.

APPENDIX II.

Record of typhoid fever cases on watershed of area investigated.

RARITAN RIVEA AREA.

NEW BRUNSWICK.

[Population, 1910, 22,398.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1905	2	1	.....	4	6	6	5	2	.....	.....	3	2	31
1906	1	.....	.....	.....	.....	1	1	2	4	2	.....	2	13
1907	.....	.....	.....	.....	.....	2	.....	5	13	7	2	4	33
1908	.....	.....	4	4	2	.....	9	3	8	2	1	.....	33
1909	.....	1	1	.....	.....	3	2	9	5	5	.....	1	27
1910	1	.....	2	.....	.....	2	2	4	3	.....	3	1	18
1911	.....	5	.....	.....	.....	.....	2	.....	.....	4	1	.....	12
1912	.....	.....	.....	1	1	.....	1	3	1	6	.....	.....	13
1913	5	.....	.....	.....	.....	.....	1	3	.....	2	2	1	14
1914	.....	.....	.....	.....	.....	.....	2	1	9	2	.....	2	16

PERTH AMBOY.

[Population, 1910, 32,425.]

1907	.....	.....	1	.....	1	.....	14	24	7	5	3	.....	55
1908	.....	.....	1	.....	.....	.....	.....	1	2	.....	1	.....	5
1909	.....	.....	.....	.....	.....	.....	.....	4	5	6	.....	.....	15
1910	.....	.....	1	.....	5	1	1	4	13	20	10	8	63
1911	1	1	.....	.....	.....	3	1	9	5	4	5	3	32
1912	.....	1	.....	.....	2	1	2	5	3	4	7	2	27
1913	.....	.....	.....	.....	.....	1	3	2	60	24	7	1	98
1914	.....	.....	.....	.....	.....	.....	.....	.....	.....	16	2	5	23

SOUTH AMBOY.

[Population, 1910, 6,943.]

1910	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	3
1911	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
1912	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
1913	.....	.....	.....	1	.....	.....	.....	1	.....	.....	1	.....	3
1914	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	1

BOROUGH OF SOUTH RIVER.[1]

[Population, 1910, 4,772.]

1907	.....	.....	.....	.....	.....	.....	3	.....	1	.....	.....	.....	4
1908	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	None.
1909	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
1910	.....	3	.....	.....	.....	.....	1	4	.....	.....	.....	.....	8
1911	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	None.
1912	.....	.....	.....	.....	.....	.....	1	3	8	6	.....	.....	18
1913–14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	None.

[1] Other cases in this area were recorded as follows:
Highland Park Borough: 1910. 1 case, November. 1911. 1 case, March. 1912. 1 case, March. 1913. No cases. 1914. No cases.
Metuchen Borough: 1910. No data. 1911. No cases. 1912. 1 case, May. 1913. 1 case, October. 1914. 1 case, January.
Raritan Township (Middlesex County): 1910. No data. 1911. 2 cases, September. 1912. 2 cases, March. 1913. 1 case, January. 1914. 1 case, December.
Sayreville Township: 1910. 1 case, September; 1 case, October; 1 case, November. 1911. No cases. 1912. 1 case, August; 1 case, October. 1913. 1 case October. 1914. No cases.

Record of typhoid fever cases on watershed of area investigated—Continued.

ARTHUR KILL AREA.

RAHWAY.

[Population, 1910, 5,367.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1906					25	1	1	1	3	4			35
1907	1		1	1	3					1			7
1908				2				4	4	1			11
1909		1	2	5	2	1						1	12
1910		11	4	1	4				1	2	1		24
1911	1		1				3					4	9
1912	4		2	3			3		1	1		1	15
1913						1		7	2				10
1914					1			1				1	3

SUMMIT.

[Population, 1910, 7,500.]

1905							1	1			3	1	6
1906	1					2	1	5	1				10
1907								1	1	2		1	5
1908	1	1	1		1							2	6
1909	4	1					1	1					7
1910							1		7		1	5	14
1911	1							3				1	5
1912	1			3									4
1913						1		1	2		2		6
1914	5	3		1					1	2			12

ELIZABETH.

[Population, 1910, 73,858.]

1905		1		1			2	9	1	5	4	2	25
1906	4		1	1	1	3	1	3	4	3	2	4	27
1907	2	1		2	3	1		2	3	3	5	1	23
1908	1	2	2	5		2	13	11	3	2		2	43
1909	4	8	9	4	2	2	2	6	5	3	3	2	50
1910	1	2	3	2	1	3	1	5	24	2	7	3	54
1911	3	2	3	4	1	1	2	2	4	8	4	3	37
1912	3	2	3	2	1	2	8	13	5	7	5	3	54
1913	6	1	2	1	2		4	7	8	7	1	2	41
1914	3	5	1		1	1	2	3	2	2	1	6	27

ROSELLE PARK.

[Population, 1910, 1,246.]

1905						1							1
1906													None.
1907								1					1
1908												1	1
1909–10													None.
1911											1		1
1912													None.
1913	1												1
1914									1				1

IRVINGTON.[1]

[Population, 1910, 12,017.]

1911			1										1
1912					1								1
1913				1					4	1	2		8
1914									1				1

[1] In the township of Woodbridge there were 7 cases of typhoid fever in 1914—3 cases in August, 1 in September, 2 in October, and 1 in December.

Record of typhoid fever cases on watershed of area investigated—Continued.

ARTHUR KILL AREA—Continued.

TOWNSHIP OF SOUTH ORANGE.

[Population, 1910, 2,979.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1905													None.
1906							3	3					6
1907								2				1	3
1908												1	1
1909											1		1
1910	1		1		1		2	6	1				12
1911		1					1		1	1		1	5
1912	2								1			1	4
1913				1					1				2
1914							1		1				2

WEST ORANGE.

[Population, 1910, 10,980.]

1905					1					1		1	3
1906			1			1	1	1	1	1			6
1907							1	1			1	1	4
1908					1	1							2
1909						3		1	1			1	6
1910							1	1			1		3
1911						2		1	4			1	8
1912								2		7	2		11
1913								1					1
1914			1	1	1			1	3	1			8

TOWNSHIP OF CRANFORD.

[Population, 1910, 3,641.]

1906					1							1	2
1907				1						1			2
1908							2				2		4
1909				3	11				1	1			16
1910							1		1				2
1911	1				1			1					3
1912					1				1	1			3
1913	1						1						2
1914													None

BOROUGH OF ROOSEVELT.

[Population, 1910, 5,786.]

1907										4			4
1908–11													None.
1912									2				2
1913			2	1		1			1	2			7
1914				1				1					2

VILLAGE OF SOUTH ORANGE.

[Population, 1910, 6,014.]

1905	2		1	2				1		1	4	4	15
1906		1		1			5	9	2	2	1		21
1907	1							1	1	2	1		6
1908									2	5	2		9
1909				1	1	1			2	2		1	8
1910			1				1	3	1		6	2	14
1911	1	2		2	2	1	1		1			3	13
1912								2	8				10
1913	1									1			2
1914										1			1

Record of typhoid fever cases on watershed of area investigated—Continued.

ARTHUR KILL AREA—Continued.

TOWNSHIP OF LINDEN.

[Population, 1910, 1,988.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1910–11													None.
1912								1					1
1913		3								2			5
1914													None.

WESTFIELD.

[Population, 1910, 6,420.]

1907							1				1		2
1908					1				1	1	2	1	6
1909	3	6	1		2								12
1910								2		1			3
1911								2	1	1			4
1912					1		1	3	1				6
1913							2		2				4
1914							2	1	1				4

EAST ORANGE.

[Population, 1910, 34,640.]

1907[1]							2		12		2	2	18
1908	1		1		1	1	3	1	2	10	1		21
1909		1	1	1			1	4	3			1	12
1910	2		1		1		4		6	2	2	7	25
1911	1				2	1	2	3		3	3	1	16
1912	1		2		1		1	6	3	2	2	2	20
1913													None.
1914	1		1		1	4		1	6	6		2	22

TOWNSHIP OF MILBURN.

[Population, 1910, 3,720.]

1906							1	1			1		3
1907								3					3
1908									1				1
1909				1					1				2
1910							1	1				1	3
1911				1									1
1912													None.
1913								1					1
1914						1							1

NEWARK.

[Population, 1910, 349,608.]

1907[1]							22	39	40	42	43	24	210
1908	17	17	5	10	15	14	14	25	19	17	18	8	179
1909	6	10	14	10	14	10	14	30	34	42	16	9	209
1910	9	6	5	7	9	8	21	37	20	32	16	9	179
1911	8	9	6	14	12	25	24	29	37	23	4	14	205
1912	4	10	13	4	20	9	25	37	20	20	16	31	209
1913	12	2	7	10	19	12	21	32	31	20	21	0	187
1914	3	2	4	15	12	18	101	28	21	25	4	11	244

[1] Cases from July on.

Record of typhoid fever cases on watershed of area investigated—Continued.

LUPATCONG CREEK AREA.

KEYPORT.[1]

[Population, 1910, 3,554.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1911–12													None.
1913				1	7	7	1				3		19
1914					2								2

SHREWSBURY AND NAVESINK RIVER AREAS.

BOROUGH OF ATLANTIC HIGHLANDS.

[Population, 1910, 1,645.]

1905–9													None.
1910										1		1	2
1911													None.
1912											1		1
1913–4													None.

TOWNSHIP OF RARITAN.

[Population, 1910, 1,583.]

1910					1	1							2
1911												1	1
1912											1		1
1913											1	2	3
1914													None.

TOWNSHIP OF MIDDLETOWN.

[Population, 1910, 6,653.]

1908													None.
1909											1		1
1910													None.
1911	2					1					2		5
1912				1			1			1		1	4
1913													None.
1914									2				2

BOROUGH OF RED BANK.

[Population, 1910, 7,439.]

1905													None.
1906		1											1
1907–8													None.
1909										1			1
1910									2				2
1911							1		2		1		4
1912	3	2						1	1				7
1913	1	1					1	5					8
1914	1	2	1			1		1					6

BOROUGH OF RUMSEN.

[Population, 1910, 1,449.]

1908												1	1
1909–11													None.
1912								3	7	1			11
1913											1		1
1914					1								1

[1] The record showed no cases of typhoid fever in the Borough of Matawan from 1910 to 1914.

Record of typhoid fever cases on watershed of area investigated—Continued.

SHREWSBURY AND NAVESINK RIVER AREAS—Continued.

LONG BRANCH.

[Population, 1910, 13,391.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1907[1]	.....	.....	.....	.....	.....	.....	.....	3	2	4	4	1	14
1908[2]	4	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	35
1909	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[3]
1910	.....	.....	.....	.....	.....	.....	.....	.....	4	2	.....	.....	6
1911	.....	.....	.....	.....	.....	1	2	1	3	56	7	18	88
1912	1	5	5	1	3	2	5	11	6	3	.....	3	45
1913	.....	2	3	1	1	1	.....	1	1	9	4	1	24
1914	.....	.....	.....	.....	.....	1	.....	6	5	1	2	1	16

BOROUGH OF HIGHLANDS.

[Population, 1910, 1,386.]

1905–12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	None.
1913	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
1914	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1

TOWNSHIP OF SHREWSBURY.[4]

[Population, 1910, 3,238.]

1910	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	2
1911	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	.....	2
1912	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	2
1913	.....	.....	1	.....	.....	.....	.....	.....	2	.....	.....	1	4
1914	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	None.

ATLANTIC COAST OF NEW JERSEY AREA.

Place.	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
Allenhurst	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Deal Beach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manasquan	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	1
Borough Spring Lake	.....	0	0	0	0	0	0	.....	.....	1	0	.....	.....	4	3
Bradley Beach	0	0	0	1	0	0	0	0	0	0	0	.....	.....	2	1
Pleasantville	9	0	0	2	0	1	0	0	0	0	4	.....	.....	7	26
Ocean City	0	0	1	0	0	0	0	0	0	0	[5] 3	2	0	8	7
Cape May City	0	0	1	1	0	2	4	5	0	2	4	.....	.....	2	3
Neptune City	0	0	0	0	0	0	0	.....	0	0	2	.....	.....	0	0
Borough of Avon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Egg Harbor City	0	0	1	0	0	2	0	1	0	1	0	.....	.....	0	4
Borough Seaside Park	0	0	0	0	0	0	0	0	0	0	0	0	0	.....	0
Beach Haven	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Borough Sea Isle City	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2
Wildwood City	0	0	0	1	0	0	0	0	0	0	2	.....	.....	3	4

[1] Cases from July on.
[2] July to December 30 cases.
[3] No record.
[4] In the township of Eatontown the records showed one case of typhoid fever in June and one in December in 1912, four cases in May, 1913, and one case in August and one in September in 1914.
The local record for the Borough of Seabright showed one case in February, one in August, and two in December in 1913, and one in October and one in December in 1914.
Local records in the Borough of Fairhaven showed one case in September, 1912, and two in the same month in 1914.
[5] 45 cases among nonresidents, probably due to eating raw clams.

Record of typhoid fever cases on watershed of area investigated—Continued.

ATLANTIC COAST OF NEW JERSEY AREA—Continued.

BELMAR. [Estimated population, 1914, 2,553.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1905	1	3	1		1					1			7
1906		1				2	1						4
1907							1			1			2
1908								2	3	1			6
1909								1					1
1910						1							1
1911					1			2		1			4
1912	2												2
1913									1				1
1914							1			1			2

ASBURY PARK.[1] [Estimated population, 1914, 100,000.]

1907							2	1			3	3	9
1908	2							1	1	3	7	3	17
1909	1		2				1	2	9	10	4		29
1910	1			1			3		2	2			9
1911		1	1			1		7	2			2	14
1912			1			1	2	2	3	7			16
1913			1			1	2	2	1	1		1	9
1914					1	1	2	2	1		1	1	9

ATLANTIC CITY.[1] [Population, 1910, 46,150.]

1900	3	0	4	1	0	1	0	4		4	1	0	18
1901	1	3	2	1	0	2	3	12	13	19	3	1	60
1902	1	0	1	2	2	2	4	10	36	15	9	2	84
1903	3	0	0	1	6	3	3	9	7	3	4	1	40
1904	3	5	2	4	3	0	9	14	6	6	0	5	57
1905	2	2	2	1	1	2	2	11	10	3	6	1	43
1906	1	2	1	2	6	3	7	10	8	14	2	3	59
1907	4	1	2	1	4	3	4	10	9	4	3	1	46
1908	1	2			6								9
1909						1	4	6	5	4	4		24
1910	1			2		1	6	12	10	12	6		50
1911	1	2	1	2			2	4	12	2	1		27
1912	1	0	1	5	4	3	6	7	1	4	1	2	35
1913	5	3				1	4	15	5	5	2	2	42
1914	1	1	1	1		2	1	9	6	11	7	1	41
1915	1	1	2				4	8	4				20

[1] Summer population.

[1] The typhoid fever records at Trenton show that 2 cases occurred at Bay Head in 1914, 1 case in 1904, and 2 cases in 1913.

No record of any cases of typhoid fever at Toms River could be found in the local records or at Trenton.

The typhoid fever records at Trenton show that there was 1 death from this disease in Barnegat in 1913, 1 case in 1910, and 3 cases in 1909. There appear to have been no cases of typhoid fever in Tuckerton from 1900 to 1914.

Island Heights Borough: 1910, no data. 1911, no cases or deaths. 1912, 1 case, July; 2 cases, August; no deaths. 1913, no cases or deaths. 1914, 1 case, October; no deaths.

Ocean Grove (not incorporated): 1910, 1 case, May; 1 case, July; 1 case, September; no deaths. 1911, 1 case, May; 1 case, September; no deaths. 1912, no cases or deaths. 1913, no cases or deaths. 1914, 1 case, July; 1 case, September; 1 death, September.

Point Pleasant Beach Borough: 1910, 1 case, September; no deaths. 1911, no cases or deaths. 1912, 1 case, July; 1 case, September; no deaths. 1913, 1 case, January; 1 case, May; 3 cases, July; 1 death, May. 1914, no cases or deaths.

Sea Girt, not incorporated and no records found.

Record of typhoid fever cases on watershed of area investigated—Continued.

MAURICE RIVER AREA.

MILLVILLE.

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
1907–8	.....	3	3	3	3	.....	.....	1	.....	.....	1	.....	14
1908–9	1	3	2	.....	.....	.....	1	.....	.....	2	.....	.....	9
1909–10	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
1910–11	4	1	3	2	1	1	.....	.....	1	1	.....	.....	14
1911–12	1	1	3	3	.....	1	.....	.....	3	.....	.....	.....	12
1912–13	1	3	4	.....	3	.....	.....	.....	.....	.....	3	.....	14
1913–14	.....	6	4	2	1	2	1	.....	.....	.....	3	1	20
1914–15	.....	1	1	1	1	3	.....	1	1	4	.....	1	14

COHANSEY RIVER AREA.

BRIDGETON.[1] [Population, 1910, 14,209.]

1907–8	3	.....	.....	.....	14	1	.....	1	.....	.....	1	.....	20
1908–9	.....	.....	7	1	3	.....	.....	.....	.....	.....	2	.....	13
1909–10	1	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	4
1910–11	2	2	3	5	2	6	6	.....	1	1	.....	.....	28
1911–12	6	4	3	2	.....	2	1	.....	.....	.....	.....	.....	18
1912–13	3	4	.....	1	3	1	.....	.....	.....	.....	1	1	14
1913–14	1	.....	.....	2	1	1	1	.....	.....	.....	28	1	35
1914–15	5	9	6	1	.....	1	3	.....	.....	.....	1	1	27

[1] No cases of typhoid fever have been reported in Greenwich Township for the past eight years and no cases could be recalled by the local physicians. It should be remembered that in this township at the village of Greenwich Pier are located the floats in which oysters are laid out before they are shipped.

Hopewell Township, which lies between Greenwich Township and the city of Bridgeton, had 11 cases of typhoid fever reported during the period from 1907 to 1915, of which 6 occurred in the month of September, the others having been chiefly in the summer and autumn.

Fairfield Township, which is below Bridgeton and on the opposite side of the river from Hopewell and Greenwich Townships, showed a record of 12 cases during the period from 1911 to 1915. Of this number, 11 cases were reported from Fairton, an unsewered village on the river below Bridgeton. The cases were rather evenly distributed throughout the year.

APPENDIX III.

Report on Ocean City Outbreak of Typhoid Fever by New Jersey Department of Health.

The Ocean City epidemic of typhoid fever is of especial interest for several reasons.

It is a marked illustration of the danger of a pollution so aptly described by Houston as being—

"Specific, and recent in character, although comparatively small in amount." It is of interest, too, in showing the value of health authorities freely communicating with the health authorities of other communities with reference to cases evidently infected in the town from which they came.

It is believed that the report on this outbreak by the New Jersey Department of Health is well worth reproducing.

OUTBREAK OF TYPHOID FEVER IN OCEAN CITY.[1]

An investigation was begun on September 12 of an outbreak of typhoid fever in Ocean City. Preceding the time of this inquiry no information had been received from the local board of health of Ocean City showing that typhoid fever had prevailed there during the summer months. With information from the bureau of health of Philadelphia, under date of September 10, stating that more than 20 cases of typhoid fever had been reported to said bureau during the preceding week in which infection was claimed to have taken place in Ocean City, and that eight of the persons thus affected had been guests at the Hotel Bellevue, the local board of health was called upon for information concerning the alleged outbreak.

The records in possession of the local health official then showed that three cases of typhoid fever had been reported during the summer. They had occurred in non-permanent resident persons, occupying separate private dwellings, under dates of July 16, August 1, and September 5. Infection in one of these cases had surely occurred before the patient came to Ocean City and one other was probably of foreign origin.

While the local board had no official knowledge that other cases had occurred, a rumor to this effect was under investigation, and evidence had been gathered showing that a number of guests at the hotels Bellevue and Oceanic were taken ill just preceding their departure from Ocean City or shortly following arrival at their homes.

An inspection was at once made at the Bellevue Hotel, which was then being closed for the season, and a request was made of the proprietor for any information in his possession which might assist in procuring the names and addresses of guests who were known to have been ill prior to leaving the hotel, or soon after their departure. This information was refused upon the ground that the lease had expired and the present management had no interest in the matter.

It was learned, however, through an office employee, that the hotel accommodated about 200 guests and employs approximately 40 persons in its management. Apparently reliable information was obtained showing that none of the employees of the hotel

[1] Thirty-fourth Annual Report Board of Health of New Jersey, 1910.

had been ill with typhoid fever. An inspection of the premises showed that the sanitary appliances in the hotel were in good repair and apparently maintained in cleanly manner. Water had been drawn from the public supply and milk obtained from a local dealer. There were no vaults on the premises, and the surroundings were found to be free from objectionable accumulations or structural conditions particularly favorable to the spread of the disease.

A visit was next made to the Oceanic Hotel, where the names of a number of persons were secured who were known to have been ill just prior to leaving or shortly following departure for their homes. Other information was freely given to aid in a search for the probable source of infection. The Oceanic Hotel accommodates about 400 guests and employs about 40 servants. In so far as known there had been no case of illness among the employees that in any way resembled typhoid fever. Except that flies were rather numerous in the kitchen and other rooms connected with the culinary department (probably due to the manner of handling and storing garbage), the sanitary conditions in and about the hotel were satisfactory.

In order that more data might be had to furnish a basis for an intelligent inquiry, a request was made of the department of health of Philadelphia for further and definite information pertaining to the number of cases reported to said department which have a history of having been infected in Ocean City. Pending receipt of this information, with the knowledge at hand, and with the assistance of the local board of health, a study of local conditions which might be responsible for the spread of infection was continued.

So far as known at that time, none of the cases had occurred among employees of the Bellevue and Oceanic Hotels. Inspection of these two premises had revealed no conditions likely to be responsible for the outbreak. The milk and water supplies were investigated with negative results and the possibility of infection from a carrier case inquired into. Considering that there were about 80 employees in the two hotels above named, none of whom had been ill, a source of infection common to guests only was sought for. Owing to the lack of information concerning the number of individuals who had contracted the disease and their movements at the time infection probably took place, few lines of inquiry entirely disassociated from the hotels in question could be carried out. In investigating the source of food supply, it was shown that oysters and clams were among the articles obtained by both hotels from a common source, through which the infection of typhoid fever might be conveyed. Both houses served raw clams and oysters to guests, but not to employees. It also appeared that this same dealer was the only person in Ocean City who had furnished little-neck clams to hotels during the summer. It was learned that these clams had been procured from various beds in near-by waters, while oysters had been obtained from a single shipper at Maurice River. The oysters were not floated or otherwise treated in a manner likely to expose them to infection after they had been received by the dealer. A portion of the clams that were used had been taken from the flats in the thoroughfare which forms the western boundary lines of the island upon which Ocean City is situated. Numerous persons had taken clams from this thoroughfare and some had disposed of their catch to the dealer in question. While no definite knowledge was yet at hand showing that any considerable number of persons who became ill had partaken of uncooked shellfish, this line of inquiry was included in the investigation, and the facts which were gathered shows a condition to have existed which is favorable to the spread of typhoid-fever infection.

It is claimed that only a small portion of the clams taken from the thoroughfare were of the little-neck variety. These were practically all used to serve on the half shell. There can be no doubt that the clams which grew on beds on the thoroughfare were taken from waters which were not only grossly polluted, but also infected by the discharges from typhoid-fever patients. Clams served by the Ocean City dealer were at times stored on a float moored at the dock at the foot of Twelfth Street. As

early as the middle of July one lot was stored on this float for a period of about 10 days. Other lots were subsequently thus stored on dates which could not be definitely fixed. More than a thousand clams, containing some little necks, were purchased by the dealer from a local fisherman during the first week in August, that were then stored on an adjoining float at the foot of Twelfth Street.

About 75 dwellings built on land bordering on the thoroughfare have house drains which discharge directly into the water. In one of these houses, 1342 Pleasure Avenue, a guest who came to the house on July 28 was taken ill with typhoid fever on August 1. The case was treated in the dwelling and the discharges were disposed of through the house drain, which discharges into the thoroughfare at a point not more than 100 yards distant from the clam floats above referred to. A drain from another dwelling discharges into the thoroughfare not more than 20 feet away from these floats.

Outlets of the public sewer discharged crude sewage into the thoroughfare at the foot of Third, Twelfth, and Fifteenth Streets. The summer population of Ocean City is approximately 30,000. The entire sewage from Ocean City is discharged into the thoroughfare, through the above-described outlets, and mingles with the waters which flow back and forth through the thoroughfare and over a number of the beds from which clams are taken, a few hundred feet distant from the sewer outlet.

The last of the data which had been requested from the department of health of Philadelphia, concerning cases that were accredited to Ocean City, was received on December 10. This list included the names of 31 persons, and makes a total of 45 cases which are known to have occurred among persons who had spent some time in Ocean City during the summer. Owing to the fact that the outbreak began about the middle of July, and that no effort was made to determine its source until the second week in September, by which time many of the hotels and cottages had been closed, and most of the infected persons had departed for their homes in other States, it became exceedingly difficult, if not practically impossible, to obtain full and accurate information for a satisfactory study of the cause of the epidemic. Unverified reports of cases have not been included, and there are doubtless other cases that have been entirely overlooked because of the obvious difficulties which were encountered when gathering the facts. A tabulation has been made of the data in hand, from which the following summary is given:

According to information furnished, the infection which caused cases 2, 3, 4, 5, and 25 must have been contracted before the individuals in which it occurred came to Ocean City, and 43 and 44 did not become ill until after the usually accepted incubation period for typhoid fever infection following their departure.

The seven cases above referred to can not, therefore, be chargeable to Ocean City, and the data relating to them have been excluded. Considering clams as a possible source of infection, these cases can, however, be counted as having a bearing on the outbreak, for in so far as is shown by this inquiry they were among the very first to occur, and include case No. 3, which occurred in the dwelling, No. 1342 Pleasure Avenue, from which a house drain discharged into the thoroughfare near the clam floats at the foot of Twelfth Street. The occurrence of these cases must have contributed typhoid infection to the sewage discharged into the thoroughfare just preceding the infection of cases which took place in Ocean City.

There are six cases in which sufficient information has not yet been furnished to determine definitely whether or not infection took place in Ocean City, but inasmuch as the data furnished favor this view, they have been included among the cases shown to have contracted the disease while there. There are 38 cases in which the infection is presumed to have taken place in Ocean City. The statement furnished showing where these persons resided and whether or not they ate raw clams in Ocean City is given in the following table:

Number of typhoid fever cases in Ocean City who had eaten clams.

	Ate raw clams.	Did not eat clams.	No information.	Total number of cases.
HOTEL.				
Oceanic Hotel	7	0	1	8
Bellevue Hotel	6	3	6	15
Normandie Hotel	4	2	0	6
Kathlue Hotel	0	0	1	1
Total	17	5	8	30
PRIVATE HOUSES IN WHICH CASES OCCURRED.				
843 Second Street	.....	1	.....	1
730 West Street	.....	1	.....	1
Fourth and West	.....	1	.....	1
1133 West	.....	1	.....	1
816 Asbury Avenue	.....	1	.....	1
Thirty-fourth Street	.....	.....	1	1
Alpha Phi Club	.....	1	.....	1
Not given	.....	.....	1	1
Grand total	17	11	10	38

The data show that none of the cases which occurred in persons residing in private dwellings ate uncooked clams, while a large percentage of the cases occurring among the hotel guests are said to have eaten them.

The preceding table also shows that 29 out of 30 cases occurred in persons residing in one of three houses. In looking for an explanation why patrons of other hotels should have escaped infection, we have the statement of the shellfish tradesman, who is said to be the only person from whom little-neck clams can be purchased in Ocean City, that very few hotels or boarding houses were supplied with clams by him to be served on the half shell. The names of the following houses are said to have served little-neck clams during the summer:

Bellevue Hotel, served frequently; Oceanic Hotel, served several times each week; Normandie Hotel, served four times during the season, hotel closed September 7; Hotels Strand, Raleigh, Illinois, and Oxford served little necks on alternating Sundays, and the Traymore and Swarthmore were supplied not more than two or three times during the entire season. One or two private houses were supplied with little-neck clams on a few occasions during the summer.

The dates of attack have not been accurately supplied in a number of cases. According to what appears to be a proper arrangement they occurred:

	Cases.
Third week in July	3
Fourth week in July	0
First week in August	4
Second week in August	10
Third week in August	9
Fourth week in August	14
First week in September	8
Second week in September	1
Third week in September	0
Fourth week in September	3
Total	45

The infection therefore appears to have been most active in the latter part of July and during the first part of August. The first few cases in the outbreak, which had

their infection before coming to Ocean City, occurred between the period of July 16 and August 4.

The home addresses of the 45 persons infected are given as: Philadelphia, Pa., 40 cases; Ocean City, 2 cases; Camden, 1 case; Wilmington, Del., 1; Unionville, Pa., 1 case.

The data concerning the ages of the persons having typhoid fever is so incomplete that it bears no significance, and is therefore not given. No cases are recorded, however, in persons under five years of age. There were 29 females and 16 males included in the outbreak. Eight cases are known to have proven fatal, and others were still very ill at the time information was procured.

Owing to the difficulty encountered in gathering much of the data used in the study of this outbreak too much reliance can not be placed upon its accuracy in some cases, and so many facts are lacking in others that no positive conclusions are justifiable as to the true source of infection which caused the epidemic, but strong presumptive evidence exists showing that many of the cases are traceable to infected clams taken from the thoroughfare.

The sewer company and all private owners of properties in Ocean City polluting the waters of the thoroughfare by discharging sewage into its waters, have been notified to discontinue such pollutions, and there should be no repetition of the conditions which led to the epidemic of the past year.

RELATED PUBLICATIONS.

[Unless marked with asterisk, copies of these Bulletins or Reprints may be obtained from the United States Public Health Service, Washington, D. C., without cost. Publications marked with asterisk may be obtained only from the Superintendent of Documents, Government Printing Office, Washington. D. C., at the cost indicated.]

HYGIENIC LABORATORY BULLETINS.

*35. Report on the Origin and Prevalence of Typhoid Fever in the District of Columbia. By M. J. Rosenau, L. L. Lumsden, and Joseph H. Kastle (including the following articles: Sanitary Inspection of Table Waters Vended in Washington, D. C., by Joseph Goldberger; Typhoid Bacillus Carriers, by Joseph Goldberger; The Longevity of B. Typhosus Outside the Human Body, by A. M. Stimson; The Alleged Rule of Intestinal Worms as Inoculating Agents in Typhoid Fever, by Ch. Wardell Stiles; A Sanitary Survey of the Drainage Basin of the Potomac River, by Joseph Goldberger). February, 1907. 361 pages. 9 maps. 7 charts. 2 diagrams. 6 figures. Paper. $1.

*44. Report No. 2 on the Origin and Prevalence of Typhoid Fever in the District of Columbia. 1907. By M. J. Rosenau, L. L. Lumsden, and Joseph H. Kastle. 63 pages. 7 maps. 4 charts. Paper. 25 cents.

52. Report No. 3 on the Origin and Prevalence of Typhoid Fever in the District of Columbia. By M. J. Rosenau, L. L. Lumsden, and J. H. Kastle. October, 1909. 160 pages. 10 charts. 10 maps. Paper.

*66. II. An Organism (pseudomonas protea) Isolated from Water, Agglutinated by the Serum of Typhoid Fever Patients. By W. H. Frost. 14 tables. 4 Charts. References. Paper. 15 cents.

*72. I. Report on an Outbreak of Typhoid Fever at Omaha, Nebr. (1909–1910). By L. L. Lumsden. 6 tables. 4 maps. 5 charts. Appendix.

II. The Water Supply of Williamson, W. Va., and its Relation to an Epidemic of Typhoid Fever. By W. H. Frost. 13 tables. 1 map. 3 charts. November, 1910. 90 pages. Paper. 15 cents.

*77. Sewage Pollution of Interstate and International Waters, with Special Reference to the Spread of Typhoid Fever. I. Lake Erie and the Niagara River. By Allan J. McLaughlin. July, 1911. 169 pages. 55 charts. 16 maps. Paper. 25 cents.

78. Report No. 4 on the Origin and Prevalence of Typhoid Fever in the District of Columbia (1909). By L. L. Lumsden and John F. Anderson. (Including articles contributed by Thomas B. McClintic and Wade H. Frost.) October. 1911. 196 pages. 27 charts. 15 maps. Paper.

*83. Sewage Pollution of Interstate and International Waters, with Special Reference to the Spread of Typhoid Fever. II. Lake Superior and St. Marys River. III. Lake Michigan and the Straits of Mackinac. IV. Lake Huron, St. Clair River, Lake St. Clair, and the Detroit River. V. Lake Ontario and the St. Lawrence River. By Allan J. McLaughlin. March, 1912. 296 pages. 91 charts. 39 maps. Paper. 30 cents.

89. Sewage Pollution of Interstate and International Waters, with Special Reference to the Spread of Typhoid Fever. VI. The Missouri River from Sioux City to its Mouth. By Allan J. McLaughlin. May, 1913. Paper. 84 pages.

96. I. Report of Investigation of Coastal Waters in the Vicinity of Gulfport and Biloxi, Miss., with Special Reference to the Pollution of Shellfish. By R. H. Creel.

II. A Comparison of Methods for the Determination of Oxygen in Waters in Presence of Nitrite. By Elias Elvove. August, 1914.

104. Investigation of the Pollution and Sanitary Conditions of the Potomac Watershed: with special reference to self-purification and the sanitary condition of shell-fish in the lower Potomac River. By Hugh S. Cumming. Plankton Studies by W. C. Purdy, and Hydrographic Studies by Homer P. Ritter. February, 1916.

PUBLIC HEALTH BULLETINS.

*51. The Causation and Prevention of Typhoid Fever, with Special Reference to Conditions Observed in Yakima County, Wash. Appendix A: The Construction and Maintenance of a Sanitary Privy. Appendix B: Measures to Prevent the Spread of Infection from the Bedside of a Typhoid Fever Patient. By L. L. Lumsden. November, 1911. 53 pages. 5 charts. 13 figures. 2 maps. Paper. 20 cents.

*65. Typhoid Fever in Rockville, Md.: Report of an Outbreak Caused by an Infected Water Supply from a Deep Well. By L. L. Lumsden. 5 cents.

74. Investigation of the Pollution of Tidal Waters of Maryland and Virginia, with special reference to shellfish-bearing areas. By Hugh S. Cumming. March, 1916.

REPRINTS FROM PUBLIC HEALTH REPORTS.

*56. Report on an Outbreak of Typhoid Fever at Des Moines, Iowa. By L. L. Lumsden. January 27, 1911. 26 pages. 2 charts. 1 map. Paper. 5 cents.

*67. Origin and Prevalence of Typhoid Fever in Fort Smith, Ark., and Measures Necessary for its Control. By W. H. Frost. October 27, 1911. 19 pages. Paper. 5 cents.

76. The Necessity for Safe Water Supplies in the Control of Typhoid Fever. By A. J. McLaughlin. March 22, 1912. 13 pages. 5 tables. Paper.

*77. Sewage-Polluted Water Supplies in Relation to Infant Mortality. By Allan J. McLaughlin. April 26, 1912. 36 pages. 24 charts. Paper. 5 cents.

104. Outbreak of Gastro-Enteritis and Typhoid Fever Due to Drinking Water on Excursion Steamer. A report of an investigation of an outbreak of gastro-enteritis and typhoid fever at Clinton, Iowa, and other towns along the Mississippi River among excursionists who had been on a river steamer July 29 and 30. By L. L. Lumsden. November 29, 1912.

157. Typhoid Fever and Gastroenteritis. A Report of an Outbreak among Passengers of the Steamship "Rochester" September-October, 1913. By Hugh de Valin. December 19, 1913.

161. The Wilmington (N. C.) Water Supply. An investigation made during November and December, 1913. By Earle B. Phelps. January 9, 1914.

168. The Water Supplies of Ships. A Discussion of the Water Furnished for Drinking Purposes and of the Methods of Sewage Disposal on Ships on Inland Waters. By Hugh de Valin. February 13, 1914.

*181. The Pollution of Tidal Waters. Its Bearing on Health and the Importance to the State of its Control. By Hugh S. Cumming. April 10, 1914. 5 cents.

*204. What is a Safe Drinking Water? By Allan J. McLaughlin. June 26, 1914. 5 cents.

*213. Safe ice. By Hugh S. Cumming. August 7, 1914. 5 cents.

214. Studies on the Self-Purification of Streams. By Earle B. Phelps. August 14, 1914.

225. The Chemical Disinfection of Water. By Earle B. Phelps. October 9, 1914.

*232. Bacteriological Standard for Drinking Water. The Standard Adopted by the Treasury Department for drinking water supplied to the public by common carriers in interstate commerce. November 6, 1914. 5 cents.

247. Sewage Disinfection for Vessels and Railway Coaches. By Leslie C. Frank. January 1, 1915.

*261. Hypochlorite Treatment of Water Supplies. Portable Plant and Field Equipment for its Administration. By H. A. Whittaker. February 26, 1915. 5 cents.

299. Essentials of Swimming-Pool Sanitation. By Wallace A. Manheimer, Ph. D. September 17, 1915.

351. Artificial Purification of Oysters. A report of experiments upon the purification of polluted oysters by placing them in water to which calcium hypochlorite has been added. By William Firth Wells. July 14, 1916.

362. The Sewage Pollution of Streams. Its relation to the public health. By W. H. Frost. September 15, 1916.